Financial Consequences of Healthcare Reforms in General Equilibrium with Risk of Default*

Youngsoo Jang†

October 2018

Abstract

This paper examines the financial consequences of three health care reforms: the Affordable Care Act (ACA), the American Health Care Act (AHCA), and single-payer healthcare. I build a general equilibrium health-capital model with risk of default where agents occasionally face emergency room events. I calibrate the model to the U.S. economy and use it to conduct a series of counterfactual experiments. I obtain two main results. First, all three healthcare reforms decrease defaults on emergency medical bills and bankruptcies - the magnitude is the largest in the economy with single-payer healthcare. Second, more redistributive healthcare reforms decrease the average default premium, while increasing the risk-free interest rate. The average borrowing cost is determined by the relative magnitude of these forces. The interaction between general equilibrium effects and policy components is central to these findings.

JEL classification: E21, H51, I13, K35.

Keywords: healthcare Reforms, Bankruptcy, Default, General Equilibrium, Affordable Care Act (ACA), American Health Care Act (AHCA), Single-payer Healthcare

---

*I thank Aubhik Khan and Julia Thomas for their valuable advice. I have benefited from comments by Satyajit Chatterjee, Mariacristina De Nardi, Pablo D'Erasmo, Pantelis Kazakis, Dirk Krueger, Pok-Sang Lam, Virgiliu Midrigan, Makoto Nakajima, Sedar Ozkan, Svetlana Pashchenko, William Peterman, Gianluca Violante, Minchul Yum and seminar participants at the Ohio State University, the Federal Reserve Board, Korea Institute for Industrial Economic and Trade, Midwest Macro Meeting in Pittsburgh, European Winter Meeting of the Econometric Society in Edinburgh, the 109th Annual Conference on Taxation, the 11th Economic Graduate Student Conference in Washington University in St. Louis, and the 6th Economics and Finance Conference in Paris. A previous version of this paper circulated with the title "Welfare Implications of healthcare Reforms based on a Model with Endogenous Health and Consumer Bankruptcy".

†Shanghai University of Finance and Economics, jangys724@gmail.com

1 Introduction

Healthcare is an essential component of macroeconomy in the U.S.[1] At the same time, it is also crucial to households' financial well-being, as health shocks are highly influential to their financial outcomes. Health shocks have impacts on bankruptcy, delinquency, credit scores, and unpaid debts. To this end, U.S. healthcare reforms have aimed at expanding the coverage of health insurances to protect against financial shocks from medical reasons. However, despite growing attention to the importance of healthcare reforms in insuring against such financial risks, there are relatively few structural approaches in which researchers examine the financial consequences of healthcare reforms. In this paper, (i) I offer a structural equilibrium approach, and (ii) apply the model to examine the financial consequences of three healthcare reforms: the Affordable Care Act (ACA), the American Health Care Act (AHCA), and single-payer healthcare.

I construct a life-cycle general equilibrium model that builds on the health capital framework of Grossman (1972, 2000) as well as the consumer bankruptcy framework used in Chatterjee et al. (2007) and Livshits et al. (2007). This general equilibrium model allows me to examine the interaction between households' decisions and changes in relative prices following healthcare reforms. In the spirit of Grossman (1972, 2000), health capital is a component of individual utility, and affects labor productivity and mortality rate. Likewise, health shocks depreciate the stock of health capital, which results in a reduction in utility, labor productivity, and survival probability. Assets market is incomplete, and households have an option to default on their medical bills and financial debts. If a debtor defaults on his debt, the debt is eliminated but his credit status becomes bad. It is recorded in his credit history, which hinders his borrowing in the future. The loan price differs across individual states, as it is determined by individual expected default probabilities.

In addition to the standard elements of the health capital model, the model has two distinctive components to capture the interactions among income, health shocks along with an institutional feature of U.S. emergency rooms, the Emergency Medical Treatment and Labor Act (EMTALA). First, the model has two types of health shocks: emergency health shocks and non-emergency health shocks. Emergency health shocks incur non-discretionary medical expenses, while individuals can choose the amount of medical expenditures for non-emergency health shocks.[2] This setting is to reflect the institutional

[1] In 2014, medical expenditures constituted 17 percent of GDP and accounted for the second largest component (21 percent) of government spending.

[2] Households do not make a decision on the amount of emergency medical costs. It is determined by

features of the EMTALA, which is an important channel for defaults on medical bills, as Mahoney (2015) and Dobkin et al. (2018) point out.[3] Second, health capital determines the distributions of the two types of health shocks. Those who accumulate a higher level of health capital stock have a lower probability of emergency medical events and severe medical conditions. Given the redistributive features of healthcare reforms, the setting allows me to explore how these policies change the distribution of health risks across income levels, which results in reshaping financial risks across households.

Using micro and macro data, I parameterize the model to the U.S. economy before the ACA by matching life-cycle and cross-sectional moments on income, bankruptcy, health insurance, medical expenditures, medical conditions and emergency room visists. The model accounts for life-cycle and cross-sectional dimensions on credit, bankruptcy, health insurance, and health inequality that are not explicitly targeted. Also, the model reproduces the correlations among income, medical conditions and emergency room visits, as founded in the Medical Expenditure Panel Survey (MEPS).

Using the model economy, I conduct a series of counterfactual experiments with the ACA, the AHCA, and single-payer healthcare. I find two main results. First, all the health reforms decline defaults on emergency medical bills and bankruptcies, and the magnitude is positively related to the extent to which healthcare reforms decreases the correlation between income and health risks. More redistributive healthcare reforms tend to decrease the correlation between income and health risks, so the rate of average default on emergency medical bills and the average bankruptcy rate are the lowest in the economy with single-payer healthcare. These rates in the economy with the ACA are the second lowest, and the rates in the economy with the AHCA follow those in the ACA.

Second, more redistributive healthcare reforms do not guarantee lower levels of the average borrowing cost. More redistributive healthcare reforms have different impacts on the default premium and the risk-free interest rate. On the one hand, these reforms reduce the overall default premium. As mentioned before, more distributive healthcare reforms

the severity of emergency medical events. Someone could doubt whether this setting is inconsistent with data. For example, he might guess that either the rich or the poor spend more on emergency room healthcare conditional on the visit of emergency rooms. However, I find that, using data from the Medical Expenditure Panel Survey (MEPS), the total amounts of charges from emergency room events is irrelevant to income levels conditional on the visit of emergency rooms, which supports the setting for emergency rooms. The results are in Appendix A.

[3] In the U.S., hospitals can check the financial ability of non-emergency patients before providing non-emergency medical treatment, but they cannot take this financial screening step before providing emergency medical treatments due to regulations in the EMTALA.

decline the overall level of default risk, and this change is reflected in individual loan prices. It turns out that the average default premium falls in this economy, which plays a role in the reduction in the overall borrowing costs. On the other hand, more redistributive healthcare reforms tend to increase the risk-free interest rate. It is required to levy additional income taxes to fund these reforms, which decreases a return for saving after tax. This decline in a return for saving after tax reduces the aggregate supply of saving, which increases the risk-free interest rate in general equilibrium, which raises the overall borrowing costs. The average borrowing cost is determined by relative magnitude of these two forces.

The model predicts that the economy with the ACA produces the lowest average borrowing cost, which means that the insurance effects on the default premium are dominant over the general equilibrium effects. Meanwhile, the single-payer case produces the highest average borrowing cost, although its default premium is the lowest. This means that, in the economy with single-payer healthcare, the general equilibrium effect dominates over the policy effect on the average default premium. More redistributive healthcare reforms increase the degree of distortions in income taxes to provide health insurance to more households, which increases the magnitude of a reduction in the aggregate supply of saving. This larger decline raises the risk-free interest rate more than the case of less redistributive reforms. Therefore, the more redistributive healthcare reforms, the stronger the general equilibrium effects. The average borrowing cost in the economy with the AHCA and that with single-payer is higher than that in the baseline economy.

The paper is in line with the literature that investigates the role of health healthcare reforms. The seminal work is that of Grossman (1972) where health is a stock and can be improved by investing individual economic resources. My model is directly built upon the framework of Grossman (1972), as health has influences on the same components, and investment in health determines the likelihood of medical events. In this literature, there are currently quantitative macroeconomic model-based studies to investigate the aggregate and distribution implications of health and healthcare reforms.[4] Among these studies, my work is closely related to two papers: Jung and Tran (2016) and Cole et al. (2012). Jung and Tran (2016) study the implications of the ACA in a general equilibrium model with investment in health capital. However, their model does not address default and bankruptcy. Cole et al. (2012) study a trade between short-run benefits from generous health insurance policies and

[4]Nakajima and Tuzemen (2015), Ozkan (2014), Pashchenko and Porapakkarm (2013), Prados (2012), Jeske and Kitao (2009), Hansen et al. (2014), Hall and Jones (2007), Ales et al. (2012), Attanasio et al. (2010) are included in this literature.

long-run effects in health investment such as non-smoking and exercise. Their modeling strategy for health risks is similar to this work, as the distribution of health shocks depends on health status. However, Cole et al. (2012) do not address a risk sharing channel against health risks through the accumulation of physical capital. Also, it does not examine the role of financial risks. My model jointly analyzes the interaction among income, health risks and financial risks.

This work is linked to empirical studies that examine the relationship between health risks and household financial well-being. The empirical studies estimate the effect of adverse health events or healthcare reforms on household financial consequences such as bankruptcy, delinquency, credit scores, and unpaid debt. Gross and Notowidigdo (2011) empirically show that Medicaid expansions for children declines the probability of bankruptcy. Mazumder and Miller (2016) find that the Massachusetts healthcare reform decrease bankruptcy, delinquency, the amount of debts and improve credit scores. Hu et al. (2018) find that Medicaid expansions under the ACA generally improve financial well-being for low-income households. Dobkin et al. (2018) show that hospital admissions reduce earnings, income, access to credit, bankruptcies, out-of-pocket medical spending and unpaid medical bills. This study provides the economic logic behind these empirical findings. This study also has a close relationship with Mahoney (2015). He finds that emergency rooms along with bankruptcy play a similar role of health insurances in the United States, as low-income individuals rely on them owing to the institutional features of the EMTALA. The model incorporates these institutional features.

The rest of the paper proceeds as follows. Section 2 demonstrates the model, defines the equilibrium, and explains the numerical solution algorithm. Section 3 describes the parameteriztion strategy and shows the performances of the model. Section 4 shows the results of the policy analysis. Section 5 concludes this paper.

2 Model

2.1 Overview

Many components of this model can be observed in the literature of health capital (e.g., Grossman (1972); Grossman (2000); Prados (2012); Ozkan (2014); Jung and Tran (2016)) and consumer bankruptcy (e.g., Chatterjee et al. (2007); Livshits et al. (2007); Athreya (2008); Nakajima and Ríos-Rull (2014)). Endogenous health allows me to investigate the welfare implications of healthcare reforms for working-age households. Compared to the old, spending on healthcare has a more substantial impact on young peoples health. Moreover, as empirical studies showed, health affects labor productivity.[5] Endogenous health is important in analyzing how healthcare reforms influence earnings over the life cycle. The consumer bankruptcy framework provide a lens through which I can examine how institutional reforms reshape the distribution of individual default risks and what the financial consequences are.

The model has two distinctive features, compared to the literature. First, I distinguish between emergency and non-emergency medical events. It is to reflect institutional features for the use of emergency rooms, which would be an important channel for medical bankruptcies in the U.S. According to the EMTALA, hospitals can check the financial ability of non-emergency patients before providing non-emergency medical treatment, but they cannot take this financial screening step before delivering emergency medical treatments. The cost is huge. Holmes and Madans (2013) show that unpaid debts in emergency departments are composed of 6% of the total cost of hospital. In addition, 55% of US emergency care is uncompensated. This institutional feature is captured by separating health shocks into emergency health shocks and non-emergency health shocks. Second, health capital affects the distribution of health shocks in a way that the higher health capital, the less sick. It is important not only to quantify the preventative effects of healthcare reforms but also to explain the income-health gradients of the micro data. I show the details in section

In the following sections, I describe the details of households, firm, financial intermediaries and government, and then define the recursive general equilibrium of its stationary and transitional economies.

2.2 Households

2.2.1 Household Environments

Demographics: The economy is populated by a continuum of households in J overlapping generations. This is a triennial model. They begin with age J_0 and work. They retire at age J_r and the maximum survival age is . In each period, the survival rate is endogenously determined. The model has an exogenous population growth rate n. There are 7 age groups, $j_g : 23-34, 35-46, 47-55, 56-64, 65-76, 77-91, 92-100$

[5] Jones (2008) and Currie and Madrian (1999) review empirical evidence on the effect of health shocks on labor outcomes.

Preferences: Preferences are represented by an isoelastic utility function over an aggregate that is itself a Constant Elasticity of Substitution (CES) function over consumption c and a current health status h_c,

$$u(c, h_c) = \frac{\left[\left(\lambda_u c^{\frac{v-1}{v}} + (1-\lambda_u) h_c^{\frac{v-1}{v}}\right)^{\frac{v}{v-1}}\right]^{1-\sigma}}{1-\sigma} \tag{1}$$

where λ_u is the weight on consumption, v is the substitution elasticity between consumption c and health status h_c, and σ is the coefficient of relative risk aversion.

Labor Income: Working households at age j receive an idiosyncratic labor income y_j given by

$$\begin{aligned} \log(y_j) &= \log(w) + \bar{\omega_j} + \phi_h \log(h_c) + \log(\eta) \\ \eta^{'} &= \rho_\eta \eta + \epsilon, \quad \epsilon \sim N(0, \sigma_\epsilon) \end{aligned} \tag{2}$$

where w is the aggregate market wage, $\bar{\omega_j}$ is a deterministic age term, h_c is a current health status, ϕ_h is the elasticity of labor income y_j to health status h_c and η is an idiosyncratic productivity shock. η follows the above AR-1 process with a persistence of ρ_η and a persistent shock ϵ of normal distribution

Health Technology: In the model, health shocks interact with health capital. First, a given health capital, I demonstrate how health shocks evolve. Next, I describe how health capital is intertemporally determined.

The model has two types of health shocks: emergency health shock ϵ_e and non-emergency health shock ϵ_n. These two shocks determine a current health status h_c in the following way:

$$h_c = (1-\epsilon_e)(1-\epsilon_n)h \tag{3}$$

where h_c is a current status of health, ϵ_e is emergency health shock, ϵ_n is non-emergency health shock, and h is the stock of health capital. Emergency health shocks ϵ_e and non-emergency health shocks ϵ_n depreciate health capital h and the remaining health capital becomes current health status h_c. It is important to note that the current health status h_c is different from the stock of health capital h.

Let us begin with emergency health shock ϵ_e. Households face emergency health shocks

ϵ_e only when they experience an emergency medical event. The probability of emergency medical events is as follows:

$$X_{er} = \begin{cases} 1 & \text{with probability } \frac{(1-h+\kappa_e)}{A_{j_g}} \\ 0 & \text{with probability } 1 - \frac{(1-h+\kappa_e)}{A_{j_g}} \end{cases} \tag{4}$$

where X_{er} is the random variable of emergency medical events, h is the stock of health capital. Regarding the probability function of emergency medical events, k_e is the scale parameter and A_{j_g} is the age group effect parameter. k_e controls the average probability of emergency room events and A_{j_g} influences how much the probability differs across age groups. Households experience an emergency medical event $X_{er} = 1$ with a probability of $(1 - h + \kappa_e)/A_{j_g}$. It implies that health capital h determines the probability of emergency medical events.[6] The more health capital, the less likely emergency medical events happen.

Conditional on an emergency medical event, $X_{er} = 1$, emergency health shocks ϵ_e evolve as follows:

$$\epsilon_e = \begin{cases} \epsilon_{se} & \text{with probability } p_{se} \text{ conditional on } X_{er} = 1 \\ \epsilon_{ne} & \text{with probability } 1 - p_{se} \text{ conditional on } X_{er} = 1 \end{cases} \tag{5}$$

$$\text{where}$$

$$0 < \epsilon_{ne} < \epsilon_{se} < 1 \quad \text{and} \quad 0 < m_e(\epsilon_{ne}) < m_e(\epsilon_{se})$$

where (ϵ_{ne}) ϵ_{se} is (non-) severe emergency health shock, p_{se} is the probability of the realization for severe emergency health shock ϵ_{se}, and $(m_e(\epsilon_{ne}))$ $m_e(\epsilon_{se})$ is the medical cost of (non-) severe emergency medical shock. Severe emergency health shock is larger than non-severe emergency health shock. One may think that severe emergency health shocks mean serious ER events such as car accidents and gunshot wounds. Non-severe emergency health shocks imply less serious ER events such as allergies and pink eyes. These emergency health shocks incur emergency medical costs $m_e(\cdot)$. It is important to note that emergency medical costs $m_e(\dot{)}$ are not a choice variable, rather it is the function of emergency health shock $\epsilon \in \{\epsilon_{ne}, \epsilon_{de}\}$. Severe emergency health shocks incur heavier medical costs than non-emergency health shocks, $m_e(\epsilon_{ne}) < m_e(\epsilon_{se})$.

[6] For example, let us assume that $\alpha_e = 1, A_{j_g} = 1$ and $k_e = 0$ and compare two households: household A with $h = 0.5$ and household B with $h = 0.8$. Then, the probability of emergency medical events for household A is 0.5, while that for household B is 0.8.

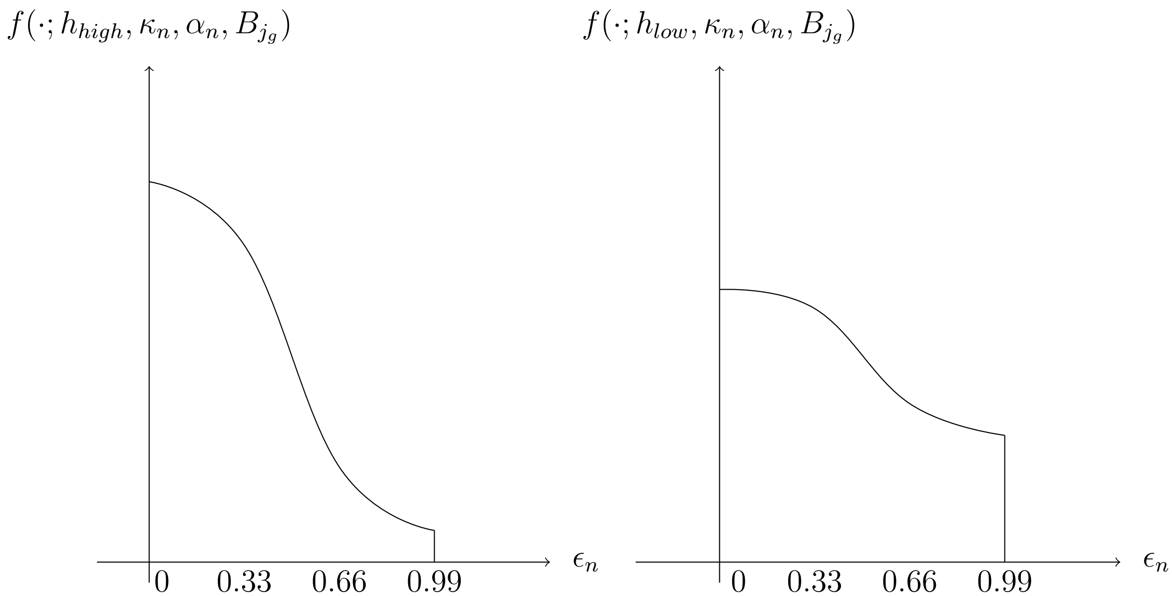


Figure 1: Distribution of Non-emergency Health Shocks across Levels of Health Capital ($h_{high} > h_{low}$)

Non-emergency health shock ϵ_n evolves as follows:

$$\epsilon_n \sim TN\left(\mu = 0, \sigma = \frac{((1/h) - 1 + \kappa_n)^{\alpha_n}}{B_{j_g}}, a = 0, b = 1\right) \tag{6}$$

where $TN(\mu, \sigma, a, b)$ is a truncated normal distribution on a bounded interval $[a, b]$, of which the mean and standard deviation of its original normal distribution are μ and σ, respective. Let us denote σ as the dispersion of the distribution of non-emergency health shocks. The dispersion σ is a function of health capital h with three parameters: κ_n, α_n, and B_{j_g}. Regarding the dispersion of the distribution of non-emergency health shock, κ_n is the scale parameter, α_n is the curvature parameter, and B_{j_g} is the age group effect parameter. k_n controls the overall size of non-emergency health shocks, α_n determines the extent to which differences in health capital affect the size of dispersion σ, and B_{j_g} influences how much the size of dispersion σ differs across age groups.

Health capital determines the distribution of non-emergency health shocks through its dispersion σ. Figure 1 illustrates how health capital determines the distribution of non-emergency health shocks. The horizontal axis indicates the size of non-emergency health shocks, and the vertical axis means the value of the probability density function of non-emergency health shocks. Given values of parameter k_n, α_n and B_{j_g}, the dispersion of non-emergency health shocks, $\sigma = \frac{((1/h)-1+\kappa_n)^{\alpha_n}}{B_{j_g}}$, decreases with health capital h. Thus, the probability density function of non-emergency health shocks tends to be more concentrated around 0 if a level of health capital h is high, as the left side of the graph in Figure 1 shows. It means that those who accumulate more stock of health capital are less likely to confront a large non-emergency health shock. On the other hand, if a household has a low level of health capital stock, the dispersion of the distribution of non-emergency health shocks is large, as the right side of the graph in Figure 1 shows. It means this agent is more likely to face a huge non-emergency health shock

To model health technology, I modify the health capital model of Grossman (1972, 2000). In the spirit of his work, health capital evolves as follows:

$$h^{'} = h_c + \psi_{j_g} m_n^{\varphi_{j_g}} = (1-\epsilon_e)(1-\epsilon_n)h + \psi_{j_g} m_n^{\varphi_{j_g}} \tag{7}$$

where $h^{'}$ is the stock of health capital in the next period, h_c is the current status of health, ϵ_e is emergency health shocks, ϵ_n is non-emergency health shocks, h is the stock of health capital in the current period, ψ_{j_g} is the efficiency of non-emergency health technology at age group j_g, φ_{j_g} is the curvature of non-emergency medical expenditure function. Households invest in health capital through non-emergency medical expenditures m_n. Then, households' total medical expenditures m are given by

$$m = m_n + m_e(\epsilon) \tag{8}$$

where m_n and $m_e(\epsilon_e)$ are non-emergency and emergency medical expenditures, respectively.

There are two key differences in this health technology, compared to that in other health capital models. First, the stock of health capital h is different from the current health status $h_c = (1-\epsilon_n)(1-\epsilon_e)$. Although the stock of health capital h determines the distributions of emergency and non-emergency health shocks, households cannot directly buy a perfect health, as the full level of health capital does not guarantee no health shock. It prevents rich and old households from always maintaining the best health status. Second, emergency and non-emergency medical expenditures differ in their features and roles. Non-emergency medical expenditure m_n is discretionary as it is a choice variable. However, emergency medical expenditures $m_e(\cdot)$ are non-discretionary as it is given by emergency health shocks ϵ_e. Moreover, only non-emergency medical expenditures m_n play a role in accumulating the stock of health capital in the next period, $h^{'}$. Emergency medical costs $m_e(\cdot)$ do not affect any accumulation of health capital. It reflects that the recovery after emergency medical treatments depends on non-emergency medical treatments. If a poor household face an emergency health shock, he will receive emergency medical treatments regardless whether he can pay for due to the EMTALA. However, this patient may not obtain enough recovery treatments due to his tight budget constraint, as recovery treatments are included in non-emergency medical treatments. Here, it is worth reminding that health capital h determines two objects: the distribution of emergency medical events X_{er}, the distribution of non-emergency health shocks $TN(0, \sigma = \frac{((1/h)-1+\kappa_n)^{\alpha_n}}{B_{j_g}}, 0, 1)$.

Survival Probability: Households' survival probability is given by

$$\pi_{j+1|j}(h_c, j_g) = 1 - \Gamma_{j_g} \cdot \exp\left(-\nu h_c\right) \tag{9}$$

where $\pi_{j+1|j}(h^{'}, j_g)$ is the survival probability of living up to age $j+1$ conditional on surviving at age j in age group j_g with the current health status h_c, Γ_{j_g} is the age group effect parameter of the survival probability, and ζ is the curvature of the survival probability concerning the stock of health capital in the next period $h^{'}$. The age group effect parameter of survival probability Γ_{j_g} controls overall age effects to death. Older age groups have a higher value of Γ_{j_g}. The curvature parameter of survival probability ν captures differences in households survival rate by current health status h_c.

Health Insurance: The health insurance plans in the benchmark model resemble those in the U.S. For working-age households, the choice set of health insurance plans is given by

$$i \in \begin{cases} \{NHI, MCD, IHI, EHI\} & \text{if } y \leq \bar{y} \text{ \& } \omega = 1 \\ \{NHI, MCD, IHI\} & \text{if } y \leq \bar{y} \text{ \& } \omega = 0 \\ \{NHI, IHI, EHI\} & \text{if } y > \bar{y} \text{ \& } \omega = 1 \\ \{NHI, IHI\} & \text{if } y > \bar{y} \text{ \& } \omega = 0. \end{cases}$$

where i is health insurance status, NHI means no health insurance, MCD is Medicaid, IHI is private individual health insurance, EHI is employer-based health insurance, y in individual income, $\bar{y}$ is the income threshold for Medicaid eligibility, ω is the offer of employer-based health insurance.

Medicaid MCD is available only for low-income working-age households. Thus, if a households income is below the income threshold for Medicaid eligibility $\bar{y}$, they can take Medicaid. Otherwise, Medicaid MCD is not available in its insurance choice. Individual private health insurance IHI is available to every working-age household. Households do not have any requirement to buy it.

Employer-based health insurance EHI is only available to those who have the offer ω from their employers. Jeske and Kitao (2009) show that the offer rate of employer-based health insurance EHI tends to be higher in high salary jobs. Thus, I assume that the offer of employer-based health insurance EHI is randomly determined, and the probability of an offer of employer-based health insurance increases with households persistent component of idiosyncratic labor productivity shock η. Explicitly, the likelihood of an offer of employer-based health insurance EHI is given by $p(EHI|\eta)$ where η is the persistent component of idiosyncratic shock on earnings. Following Jeske and Kitao (2009), the offer probability $p(EHI|\eta)$ increases with η.

The price of private health insurances is given by

$$p_{i'}(h_c, j_g) = \begin{cases} 0 & \text{if } i^{'} = NHI \text{ or } i^{'} = MCD \\ p_{IHI}(h_c, j_g) & \text{if } i^{'} = IHI \\ p_{EHI} & \text{if } i^{'} = EHI \end{cases}$$

where $p(\cdot, \cdot, \cdot)$ is a health insurance premium. $iI^{'}$ is the purchase of health insurance for the next period, h_c is current health status, j_g is age group. $p_{IHI}(h_c, j_g)$ is the health insurance premium of private individual health insurance IHI for insured whose health status is h_c within age group j_g. p_{EHI} is the premium of employer-based health insurance.

Individual private health insurance IHI and employer-based health insurance EHI differ in the price system. Individual health insurance has premiums $p_{IHI}(h_c, j_g)$, where h_c and j_g are a current health status and age group, respectively. The setting is based on the individual private health insurance market of the U.S. before the ACA. Individual private health insurance providers are allowed to differentiate prices by using customers pre-existing conditions, age, and smoking. Contrary to the separating equilibrium of individual health insurance IHI, employer-based health insurance has one single premium p_{EHI}. This price is independent of any individual state, which reflects that in the U.S., the providers of employer-based health insurance cannot discriminate employees based on their preconditions due to the Health Insurance Portability and Accountability Act (HIPAA). In addition, a fraction $\psi_{EHI} \in (0, 1)$ of the premium p_{EHI} is covered by employers, so insurance holders pay $(1 - \psi_{EHI}) \cdot p_{EHI}$.

All of the health insurances provide coverage $q_i \cdot m$ and $(1 - q_i)m$ becomes an out-of-pocket medical expenditure of insured household. For example, Medicaid holders, Medicaid MCD covers $q_{MCD} \cdot m$ and $(1 - q_{MCD}) \cdot m$ become their out-of-pocket medical expenditures.

Retired households use Medicare. Medicare is public health insurance for elderly households. I assume that all of the retired households use Medicare and do not access private health insurance market.

Default: The model has two types of default based upon the source of debt: financial default and non-financial default. Following Chatterjee et al. (2007), Livshits et al. (2007) and Nakajima and Ríos-Rull (2014), the financial default is modeled to capture the procedures and consequences of Chapter 7 bankruptcy.[7] The non-financial default is modeled to reflect the features of the Emergency Medical Treatment and Labor Act (EMTALA).

Households have two kinds of credit status: good credit status and bad credit status. "Good credit status" means that there is no bankruptcy on the credit record. Bad credit status implies that bankruptcy is recorded for this household on the credit record. These credit statuses determine the range of feasible actions of households in the financial markets.

Good credit status households can either save or borrow through unsecured debt. They can default on both financial debts and medical debts, by filing for bankruptcy. In the period of filing for bankruptcy, these households can neither save nor dissave. They have bad credit status in the next period. If a household with good credit status either have no debt or pay back its unsecured debt, it preserves its good credit status for the next period.

Bad credit status households pay the cost of "Bad credit status" as much as χ portion of their earnings for each period. Households with bad credit status can save assets, but cannot borrow from financial intermediaries. Because of the absence of financial debt, they do not conduct financial default. However, they can default on emergency medical expenses, as the EMTALA enforces hospitals to provide emergency medical treatments to patients on credit regardless patients' ability to pay back the emergency medical costs. In the period of defaulting on emergency medical expenses, these households cannot save and preserve bad credit status in the next period. Unless they default, with an exogenous probability λ, the bad credit status changes to good credit status in the next period.

[7] Chapter 7 covers 70 percent of household bankruptcies. The other type of household bankruptcy is Chapter 13, which I do not address here.

Tax System and Government Budget: Taxes are levied from two sources: payroll and income. On the one hand, Social security and Medicare are financed from payroll tax. τ_{ss} is the payroll tax rate for Social security, τ_{med} is that for Medicare. On the other hand, income tax covers the government expenditure, G, Medicaid, q_d, and the subsidy of employer-based health insurance ,ψp_e I choose the progressive tax function from Gouveia and Strauss (1994), as this has been widely used in the macroeconomic policy literature. The income tax function $T(y)$ is given by

$$T(y) = a_0\{y - (y^{-a_1} + a_2)^{-1/a_1}\} + \tau_y y \tag{10}$$

where y is taxable income. a_0 means the upper bound of the progressive tax as income y goes infinite. a_1 determines the curvature of the progressive tax function, and a_2 is a scale parameter. To use Gouveia and Strauss's (1994) estimation result, I take their estimates in a_0 and a_1. a_2 is calibrated to match a target that is the fraction of total revenues financed by progressive income tax is 65% (OECD Revenue Statistics 2002). τ_y is chosen to balance the total government budget.

2.2.2 Household Dynamic Problems

Here, I summarize household decision problem. Appendix B describes the details of household dynamic problems in recursive form.

The economy is populated by overlapping generations of households. They experience two phases of the life-cycle: the working phase and the retirement phase. For working-age households, each period consists of two sub-periods. At the beginning of sub-period 1, either good or bad credit status is given and health insurance status is determined by the decision on the purchase of health insurance in the previous period. Households are subject to uninsurable idiosyncratic shocks to their efficient units of labor and health shocks. The health shocks affect households utility, labor productivity, and their mortality. The health shocks are divided into two types: emergency and non-emergency health shocks, to reflect institutional features in the Emergency Medical Treatment and Labor Act (EMTALA).[8] Emergency health shocks incur specific sizes of non-discretionary medical costs.[9] How-

[8]The EMTALA requires hospitals with emergency departments to screen and treat an emergency medical condition, regardless of patients ability to pay or their insurance status. More details will be in the next section.

[9]It means that the amount of emergency medical costs is independent of households' income. This setting

ever, regarding non-emergency health shocks, households make a decision on how much to spend on healthcare. After the realization of all the shocks, households choose whether to default on their debt.

In sub-period 2, the available choices differ with credit status and default decision in sub-period 1. Let us begin with problems with good credit. Non-defaulters with good credit make decisions on consumption, saving or debt, the purchase of health insurance for the next period and non-emergency medical expenditures. They pay out-of-pocket medical costs of which the amount differs in insurance status. If a household purchased health insurance in the previous period, the insurance company covers a part of its medical expenditure. The rest of the medical expense is the household's out-of-pocket medical expenditure. If a household did not purchase any health insurance in the previous period, the total medical expenditure is the same as the household's out-of-pocket medical expenditure. They keep staying with the good credit status in the next period. Defaulters with good credit can neither save nor dis-save in this period, and they make decisions on consumption, health insurance for the next period and non-emergency medical expenditures. As non-defaulters with good credit do, They pay out-of-pocket medical costs.

Working households with bad credit face the following problems. Non-defaulters with bad credit are not allowed to borrow and pay a pecuniary cost of bad credit status as much as some fraction of their earnings. The other decision-making problems are almost the same as those of non-defaulters with good credit. They choose consumption, health insurance for the next period and non-emergency medical expenditures. Non-defaulters with bad credit pay out-of-pocket medical costs as working households with good credit do. Their credit status is randomly determined in the next period. Defaulters with bad credit pay a pecuniary cost of bad credit status as much as some fraction of their earnings. They can neither save nor dis-save, and they make decisions on consumption, health insurance for the next period and non-emergency medical expenditures. They pay out-of-pocket medical costs as working households with good credit do. Defaulters with bad credit also do not pay back emergency medical costs.[10] They keep staying with bad credit status in the next period.

Retired households do not have any labor income but receive social security benefits.

is supported by evidence in micro data. Using data from the MEPS, I find that, conditional on the use of emergency rooms, the amount of emergency room charges is irrelevant to households' income. More details will be in the next section.

[10]They do not have any debt via financial sectors, as those with bad credit cannot borrow regardless of their default decision.

Since they do not have uncertain labor income, they do not make unsecured loans. Instead, they face a natural borrowing limit to which only retired household with good credit status can access. All retired households have Medicare and do not use any private health insurance. At the beginning of each period, retired households face emergency health shocks and non-emergency health shocks. They make decisions on consumption, saving or debt, and non-emergency medical expenditures. They pay out-of-pocket medical costs. Retired households with good credit keep their credit status, but the credit status of retired households with bad credit is randomly determined in the next period.

2.3 Firm

The economy has a representative firm. The firm maximizes its profit by solving the following problem,

$$\max_{K,N} \{zF(K,N) - wN - rK\} \tag{11}$$

where z is the Total Factor Productivity (TFP), K is the aggregate capital stock, N is aggregate labor and r is the capital rental rate.

2.4 Financial Intermediaries

There are competitive financial intermediaries and loans are defined by each individual state. It implies that with the law of large numbers, ex post realized profits of lenders are zero for each type of loans. The lenders can observe the state of each borrower and the price of loans is determined, using good credit status households' default probability and the risk-free interest rate.[11]

Specifically, the default probability of a household with good credit status G, a total debt $a^{'}$, insurance purchase status $i^{'}$, health capital for next period $h^{'}$, current age j and current idiosyncratic earnings shock η in the next period is given by

$$d(a^{'}, i^{'}, h^{'}; j, \eta) = \tag{12}$$

$$\sum_{\epsilon_n^{\prime}, \epsilon_e^{\prime}, \eta^{\prime}, \omega^{\prime}} \pi_{\epsilon_e^{\prime}|h^{\prime}} \pi_{\epsilon_n^{\prime}|h^{\prime}} \pi_{\eta^{\prime}|\eta} \pi_{\omega^{\prime}|\eta^{\prime}} \mathbb{1}_{\{v^{G,N}(a^{\prime}, i^{\prime}, h^{\prime}, \epsilon_e^{\prime}, \epsilon_n^{\prime}, \eta^{\prime}, \omega^{\prime}, j+1) \leq v^{G,D}(i^{\prime}, h^{\prime}, \epsilon_e^{\prime}, \epsilon_n^{\prime}, \eta^{\prime}, \omega^{\prime}, j+1)\}}$$

[11]Note that households with bad credit status cannot access the financial market.

, where $\pi_{h'|\epsilon_e'}$ is the probability of emergency health shock ϵ_e in the next period conditional on health capital $h^{'}$ for next period, $\pi_{h'|\epsilon_n'}$ is the probability of non-emergency health shock ϵ_n in the next period conditional on health capital $h^{'}$ for next period, $\pi_{\eta|\eta'}$ is the transitional probability of idiosyncratic shocks on earnings $\eta^{'}$ conditional on the current idiosyncratic shocks on earnings η and $\pi_{\eta|\omega}$ is the probability of the offer of employer-based health insurance in the next period conditional on the current current idiosyncratic shocks on earnings η.

The zero-profit condition of the financial intermediaries that make a loan of amount $a^{'}$ to households with age j, the current idiosyncratic labor productivity η, health capital $h^{'}$ for next period and health insurance $i^{'}$ for next period is given by

$$(1 + r^{rf})\ q(a^{'}, i^{'}, h^{'}; j, \eta)\ a^{'} = (1 - d(a^{'}, i^{'}, h^{'}; j, \eta))\ a^{'} \tag{13}$$

, where r^{rf} is the risk-free interest rate and $q(a^{'}, i^{'}, h^{'}; j, \eta)$ is the discount rate of the loan price.[12] Then, the discount rate of the loan price $q(a^{'}, i^{'}, h^{'}; j, \eta)$ is

$$q(a^{'}, i^{'}, h^{'}; j, \eta) = \frac{1 - d(a^{'}, i^{'}, h^{'}; j, \eta)}{1 + r^{rf}}. \tag{14}$$

2.5 Hospital

The economy has a representative agent hospital. For convenience, I denote household state s as $(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega)$ and credit status $v \in \{G, B\}$, the hospital earns the following revenue:

$$m_n(\mathbf{s}, j) + (1 - g_d(\mathbf{s}, j))\ m_e(\epsilon_e) + g_d(\mathbf{s}, j)\ \max(a, 0) \tag{15}$$

,where $m_n(\mathbf{s}, j)$ is the decision rule of non-emergency medical expenditure with households' state s at age j. $m_e(\epsilon_e)$ is emergency medical expenses for emergency health shocks ϵ_e, and $g_d(\mathbf{s}, j)$ is the decision rule of default with households' state s at age j. All households always pay non-emergency medical expenditures, m_n, regardless whether to default or not, as the hospital can check patients' financial ability before providing non-emergency medical treatments. However, the payment amount for emergency medical treatments

[12]The financial intermediaries take into account households' health insurance $i^{'}$ for next period and health capital $h^{'}$ for next period to price loans. It is a necessary assumption to solve the model, as any pooling equilibrium does not exist under symmetric information between lenders and borrowers. Solving default models under asymmetric information is beyond the scope of this paper.

$m_e(\epsilon_e)$ depends on individual default decisions. It is because the Emergency Medical Treatment and Labor Act (EMTALA) enforces hospitals to provide emergency medical treatments regardless whether the patients can pay back the emergency medical bills or not . Non-defaulters repay all of their emergency medical expenditures to the hospital, but defaulters provide their assets instead of paying emergency medical expenses. If the asset level of these individuals is below 0 (debt), the hospital receives no payment.

For each period t, the hospital profits are given by

$$\sum_{j=J_0}^{\bar{J}} \int \{[m_n(\mathbf{s},j) + (1-g_d(\mathbf{s},j))\, m_e(\epsilon_e) + g_d(\mathbf{s},j)\, \max(a,0)] - \frac{(m_n(\mathbf{s},j) + m_e(\epsilon_e))}{\zeta}\} d\mu_t(\mathbf{s},j) \tag{16}$$

, where ζ is the mark-up of the hospital and $\mu_t(\mathbf{s},j)$ is the measure of households at age j with state s. Following Chatterjee et al. (2007), the mark-up ζ is adjusted to have zero profits in the equilibrium.[13]

It is important to note that the mark-up of the hospital ζ is an instrument through which we can evaluate the efficiency of healthcare policies in terms of healthcare providers, because the size of hospital's mark-up ζ increases with unpaid medical debt.

2.6 Equilibrium

Appendix D defines a recursive competitive equilibrium.

2.7 Numerical Solution Algorithm

Here, I describe the key ideas of this numerical solution algorithm. Appendix F demonstrates each step of the algorithm with details.

There are substantial computational burdens in solving the model. The model has a large number of individual state variables, and loan prices depend on the state of individuals due to the endogenous default setting. Moreover, the model has many parameters that have to be adjusted to match cross-sectional and life cycle moments in the model with those in the data.

[13] Note that the object of default is here only emergency medical expenditures, while that in Chatterjee et al. (2007) is all the medical expenditures.

To solve the model, I use Jang and Lee's (2018) endogenous grid method. They develop an endogenous grid method for models with a default option, by extending Fella's (2014) method. Fella (2014) develops an endogenous grid method to solve models with discrete choices under an exogenous borrowing limit. One of the main contributions in Fella (2014) is an algorithm identifying concave regions over the solution set, to which Carroll's (2006) endogenous grid method is applicable. However, Fella's (2014) endogenous grid method is not directly applicable to models with default options, as these models do not have any predetermined feasible set of solutions. Based on the theoretical findings of Arellano (2008); Clausen and Strub (2017), Jang and Lee (2018) add a numerical procedure of finding the lower bound of feasible sets for the solution to Fella's (2014) algorithm that identifies concave regions over the solution sets, which allows me to use the endogenous grid method to solve this model.

Definition 2.7.1. For each $(\bar{i}', \bar{h}'; j, \eta)$, $a'_{rbl}(\bar{i}', \bar{h}'; j, \eta)$ is ***the risky borrowing limit*** if

$$\forall a' \geq a'_{rbl}(a', \bar{i}', \bar{h}'; j, \eta),$$
$$\frac{\partial q(a', \bar{i}', \bar{h}'; j, \eta) a'}{\partial a'} = \frac{\partial q(a', \bar{i}', \bar{h}'; j, \eta)}{\partial a'} a' + q(a', \bar{i}', \bar{h}'; j, \eta) > 0.$$

I numerically compute the risky borrowing limit for each state, and take it for the lower bound of feasible sets for the solution a'. Of course, to use the endogenous grid method, the FOC is required. The following theorem allows me to use the endogenous grid method.

Proposition 2.7.1. *Given a pair of (ϵ_e, ϵ_n), for any $(\bar{i}', \bar{h}', j, \eta)$ and for any $a' \geq a'_{rbl}(\bar{i}', \bar{h}'; j, \eta)$,*
(i) the First Order Condition (FOC) of asset holdings a' exists,
(ii) the FOC is as follows:

$$\frac{\partial q(a', \bar{i}', \bar{h}'; j, \eta) a'}{\partial a'} \frac{\partial u(c, (1-\epsilon_e)(1-\epsilon_n)\bar{h})}{\partial c} = \frac{\partial W^G(a', \bar{i}', \bar{h}', \eta, j+1)}{\partial a'}, \tag{17}$$

Proof. See Appendix C. □

3 Parameterization

I calibrate the model to capture cross-sectional and life cycle features of the U.S. economy before the Affordable Care Act (ACA), because the period of the ACA is too short to be considered as the steady state of the U.S. healthcare system. To reflect these features, I take information from multiple micro data sets. In particular, I use the Medical Expenditure Panel Survey (MEPS) to capture important cross-sectional and life cycle dimensions on the use of emergency rooms, medical conditions, and medical expenditures.[14]

To calibrate the model, I separate parameters into two groups. The first set of parameters is determined outside the model. I choose the values of these parameters from macroeconomic literature and policies. The other set of parameters requires solving the stationary distribution of the model to minimize the distance between moments generated by the model and their empirical counterparts. Table 1 shows the values of parameters resulting from the calibration, Table 2 summarizes the targeted aggregate moments and the corresponding moments generated by the model, and Figure 2 shows the targeted life-cycle moments and the corresponding model-generated moments.

Table 1: Benchmark Parameter Values

Parameter	Description	Internal	Value
Demographics			
J_0	Initial age	N	23
J_r	Retirement age	N	65
$\bar{J}$	Maximum length of life	N	100
π_n	Population growth rate (percent)	N	1.2%
Preferences			
λ_u	Weight on consumption	Y	0.532
v	Elasticity of substitution b.w c and h_c	Y	0.332
σ	Risk aversion	N	3 (De Nardi et al. (2010))
β	Discount factor	Y	0.747
Labor Income			
$\bar{\omega_j}$	Deterministic life-cycle profile	N	{0.0905,-0.0016}*
ϕ_h	Elasticity of labor income to health status	N	0.594
ρ_η	Persistence of labor productivity shocks	Y	0.851
σ_ϵ	Standard deviation of persistent shocks	Y	0.575
Health Technology			
κ_e	Scale of ER health shocks	Y	0.283
A_{j_g}	Age group effect on ER health shocks	Y	{1, 1.322, 1.482, 1.615, 1.872, 1.780}
p_{se}	Probability of drastic ER health shocks	N	0.2
κ_n	Scale of Non-ER health shocks	Y	0.019
α_n	Dispersion of Non-ER health shocks	Y	0.551
B_{j_g}	Age group effect of Non-ER health shock	Y	{1, 0.693, 0.406, 0.256, 0.129, 0.010}

[14]The details of data selection process are in Appendix A.

Table 1 continued from previous page

Parameter	Description	Internal	Value
ψ_{j_g}	Efficiency of health technology	Y	{0.516, 0.501, 0.552, 0.547, 0.460, 0.428}
φ_{j_g}	Curvature of health technology	Y	{0.418, 0.249, 0.255, 0.265, 0.498, 0.566}
Survival Probability			
Γ_{j_g}	Age group effect on survival rate	Y	{0.004, 0.001, 0.02, 0.03, 0.12, 0.28, 0.56}
ν	Elasticity of survival rate to health status	N	0.226 (Franks et al. (2003))
Health Insurance			
$\bar{y}$	Income threshold of Medicaid eligibility	Y	0.042
q_{MCD}	Medicaid coverage rate	N	0.7
q_{IHI}	IHI coverage rate	N	0.55
q_{EHI}	EHI coverage rate	N	0.7
q_{med}	Medicare coverage rate	N	0.55
p_{med}	Medicaid Premium	N	0.021
$p(EHI\|\eta)$	EHI offer rate	N	Appendix
ψ_{EHI}	Subsidy of EHI	N	0.8
ξ_{IHI}	Markup of IHI	Y	1
ξ_{EHI}	Markup of EHI	Y	1
Default			
ξ	Cost of bad credit status	Y	0.148
λ	1/Duration of bad credit status	N	0.333
Tax and Government			
ss	Social security benefit	N	0.256
τ_{ss}	Social Security tax	Y	0.077
τ_{med}	Medicare payroll tax	Y	0.054
G	Government spending/ GDP	N	0.18
a_0	Upper bound of the progressive tax fnc	N	0.258 (Gouveia and Strauss (1994))
a_1	Curvature of the progressive tax fnc	N	0.768 (Gouveia and Strauss (1994))
a_2	Scale of the progressive tax fnc	Y	1.225
τ_y	Proportional tax rate	Y	0.078
Firm			
z	Total factor productivity	Y	0.472
θ	Capital income share	N	0.36
δ	Depreciation rate	N	0.24
Hospital			
ζ	Mark-up of hospital	Y	1.037

The model period is triennial . A unit of output in the model is the U.S. GDP per capita in 2000 ($\$36245.5$).

Demographics: The model period is triennial. Households enter the economy at age 23

Table 2: Targeted Aggregate Moments

Moment	Empirical value	Model value
Risk-free Interest rate (percent)	4	4
AVG of bankruptcy rates (percent)	0.84	0.91
Total Medical Expenditures/GDP	0.163	0.162
CV of medical expenditures	2.67	2.43
Corr b.w. consumption and medical expenditures	0.158	0.158
Auto correlation of earnings shocks	0.957	0.952
STD of log earnings	1.29	1.29
Fraction of ER users aged b.w. 23 and 34	0.125	0.119
AVG of health shocks aged b.w. 23 and 34	0.116	0.120
Individual health insurance take-up ratio	0.116	0.114
Employer-based health insurance take-up ratio	0.685	0.670
Working-age households' Medicaid take-up ratio	0.044	0.042

The model period is triennial . I transform triennial moments into the annual moments. A unit of output in the model is the U.S. GDP per capita in 2000 ($\$36432.5$).

and retire at age 65. Since the mortality rate is endogenous, life spans differ across households. Their maximum length of life is 100 years. These are corresponding to $J_r = 15$ and $\bar{J} = 26$. The population growth rate π_n is chosen to be 1.2 percent that is consistent with annual population growth rate in the U.S.

Preferences: Preferences are represented by a power utility function over a CES aggregator over consumption and health status. λ_u is the weight of non-medical consumption on the CES aggregator in the utility function. λ_u is chosen to match the ratio of the total medical expenditures to output of 0.17 in the National Health Expenditure Accounts (NHEA). v is the elasticity of substitution between non-medical consumption and current health status, which is chosen to target the correlation between non-medical consumption and medical expenditures of 0.158 in the PSID. The value is 0.312, which implies that the marginal utility of non-medical consumption increases with health status. This result is consistent with the empirical finding of Finkelstein et al. (2013). σ is the coefficient of relative risk aversion, which is chosen by following De Nardi et al. (2010). β is the discount factor of households. It is chosen to match an equilibrium risk-free interest rate of 4 percent.

Labor Income: To obtain the deterministic life-cycle profile of earnings $\bar{\omega_j}$, I take the following steps. First, in the MEPS, I choose the Physical Component Score (PCS) as

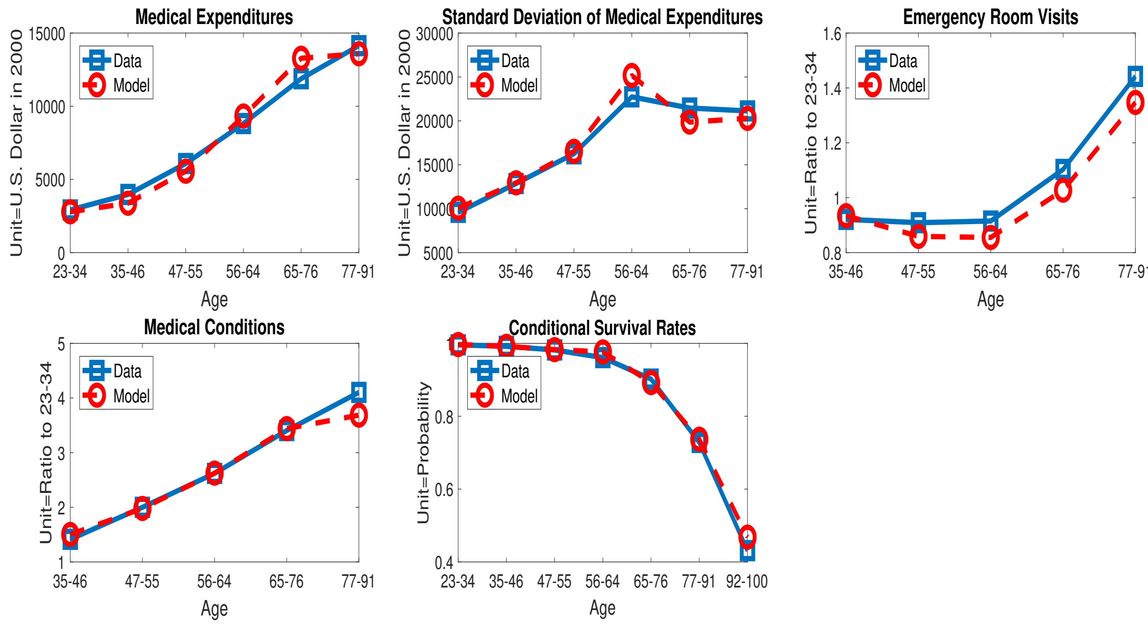


Figure 2: Targeted Life-cycle Moments

the counterpart of health status in the model.[15] I normalize the PCS by dividing all of the observations by the highest score in the sample. Second, by using the panel structure of data from the MEPS, I run regression of the difference in log of labor income on differences in age's square, education, sex, and the PCS.[16] I choose the summation of the age and age's square terms as the deterministic life-cycle profiles of earnings $\bar{\omega_j}$. ϕ_h is set to be based on the estimates of the coefficient of the PCS. ρ_η is chosen to match the auto-correlation of idiosyncratic part $\phi_h \log(h_c) + \log(\eta)$ with the auto-correlation of earnings shocks without health component of 0.957 in Storesletten et al. (2004). σ_ϵ is chosen so that the model generates a standard deviation of 1.29 for the log earnings in the Survey of Consumer Finance (SCF) (Díaz-Giménez et al. (2011)).

Health Technology: I choose the scale parameter of the function for emergency health shocks κ_e to target the average fraction of emergency room users aged between 23 and 34 of 0.125 in the MEPS. A_g governs differences in emergency room visits by age group. It is chosen to match the ratios of the fraction of emergency room visits for each age group to

[15]The PCS is a continuous health measure between 0 and 100 that indicates individual physical condition.

[16]It is absorbing individual fixed effects. Further, One may worry about some endogeneity due to a reverse causality from labor income to health, but empirical studies including Currie and Madrian (1999) and Deaton (2003) show that it is difficult to find a direct effect of labor income on health.

that of households aged between 23 and 34. Figure 2 shows that the ratios of age groups to 23-34 in data are close to those generated by the model. p_{se} is the probability of extreme emergency medical event conditional on an occurrence of an emergency medical event. I choose these extreme emergency medical events as emergency events that incur the top 20 percent of emergency medical expenses. κ_n is chosen to target the average health shocks of households aged between 23 and 34 of 0.125 in the MEPS. α_n determines the degree of differences in health shocks across levels of health capital. It is selected to target the coefficient of variation of medical expenditures of 2.67 in the MEPS. B_{j_g} is set to match the ratios of the average of medical conditions trasnformed by health shocks for each age group to that of households aged between 23 and 34. Figure 2 shows that the model generates a similir age profile of medical conditions. ψ_{j_g} is set to match the average of medical expenditures for each age group. φ_{j_g} is chosen to target the standard deviation of medical expenditures for each age group. Figure 2 shows that the the life-cycle profiles of mean and standard deviation for medical expenditures in the data are close to those generated by the model.

Survival Probability: Γ_{j_g} controls disparities in survival rate across age groups. Γ_{j_g} is chosen to target the average survival rates for each age group. ν governs the predictability of the PCS on the survival rate. I choose ν based on the estimate of Franks et al. (2003). They use a little bit different type of health measure from the MEPS. Although the MEPS uses the SF-12 as its PCS, Franks et al. (2003) chooses the SF-5 as their PCS. Despite the difference in the types of PCS, Østhus et al. (2012); Lacson et al. (2010); Rumsfeld et al. (1999) find that different types of PCS are highly correlated. Based on their finding, I use the estimate of Franks et al. (2003) by transforming his five-year result to three-year's and by rescaling 0-100 scale into the relative scale of the model in which health status is represented by a relative health status to the healthiest in the economy.

Health Insurance: The income threshold for Medicaid eligibility $\bar{y}$ is chosen to match the percentage of Medicaid taker among working-age households of 4.4 percent in the MEPS. Health insurance coverages, q_{MCD}, q_{IHI}, q_{EHI}, and q_{med}, are chosen to match the fraction out-of-pocket medical expenditures to the total medical expenditures for each type of health insurance. The Medicare Premium p_{med} is chosen to be consistent with 2.11 percent of GDP per capita, which is based on the finding in Jeske and Kitao (2009). The offer rates of employer-based health insurance $p(EHI|\eta)$ is set to target the offer rates across earnings levels in the MEPS. For each age group j_g, I calculate the conditional offer rates given a level of earnings in the data. Then, I draw a map the offer rate in the data into the stationary distribution of earnings shocks in the model and calculate the conditional offer rate $p(EHI|\eta)$. The subsidy for employer-based health insurance ψ_{EHI} is chosen so that employer-based health insurance takers pay 20 percent of the premium. ξ_{IHI} and ξ_{EHI} are chosen up to target to the take-up ratio of individual private health insurance and employer-based health insurance, respectively.

Default: The cost of bad credit status ξ is chosen to match the average Chapter 7 bankruptcy rate in Livshits et al. (2007). λ is chosen to match the average duration of exclusion that is 10 years on Chapter 7 bankruptcy filing.

Tax and Government: ss is chosen to match a replacement rate of 40 percent. The social security tax τ_{ss} is chosen to balance the government budget for Social Security. τ_{med} is set to balance the government budget for Medicare. Non-medical government spending is set to be consistent with 18 percent of the U.S. GDP. a_0 and a_1 are taken from Gouveia and Strauss (1994). As Jeske and Kitao (2009) and Pashchenko and Porapakkarm (2013) do, the scale parameter of the income tax function a_2 is chosen to match the average of fractions of tax revenue financed by progressive income tax of 65 percent, which is the average value of the OECD member countries. The proportional income tax τ_y is chosen to balance the government budget constraint.

Firm: Total factor productivity z is chosen to normalize output as 1. θ is chosen to reproduce that the share of capital income is 0.36. The depreciate rate γ is annually 8 percent.

Hospital: The mark-up of hospital ζ is chosen to reproduce the zero profit of the hospital.

3.1 Model Performance

Before conducting a series of counterfactual experiments for three healthcare reforms, I show the performance of the model by checking how consistent the untargeted results of the model are with their empirical counterparts.

Life-cycle Dimensions: Figure 3 demonstrates the life-cycle profiles of the average consumption, earnings, and assets. The shape of the consumption profile is concave and relatively flatter than other two profiles. Earnings profiles increases until the middle 40s and decline until retirement. After retirement, households receive social security benefits. Households save assets until their retirement and spend them afterward. The shape of three profiles resembles that of their empirical counterparts, which are documented in Heathcote et al. (2010) and Díaz-Giménez et al. (2011).

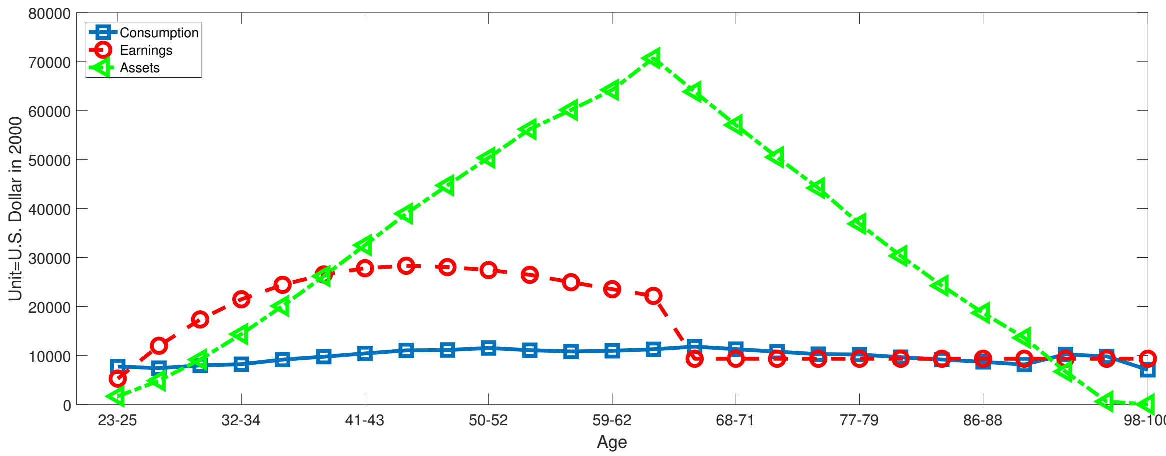


Figure 3: Age Profiles of Consumption, Earnings and Assets

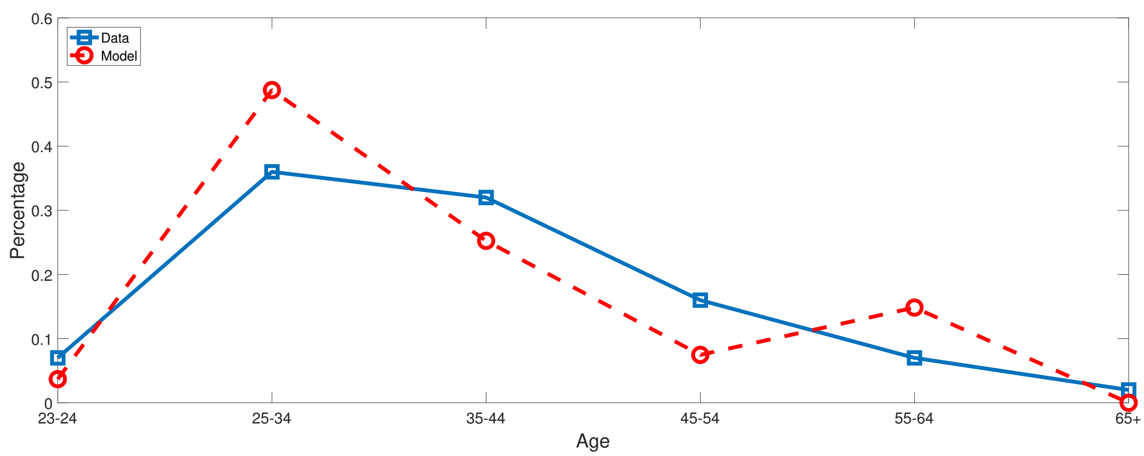


Figure 4: Age Profiles of Bankruptcy Filings
Data Source: Sullivan et al. (2001)

Figure 4 displays the profiles of the fraction of bankruptcy filings over the life-cycle. In data, the life-cycle profile of bankruptcy filings is hump-shaped, and bankruptcy filers aged between 25 and 44 consist of more than a half of the total bankruptcy filers. The model broadly reproduces these features well. It means that the model is successful in reflecting how default risks evolve over the life-cycle.

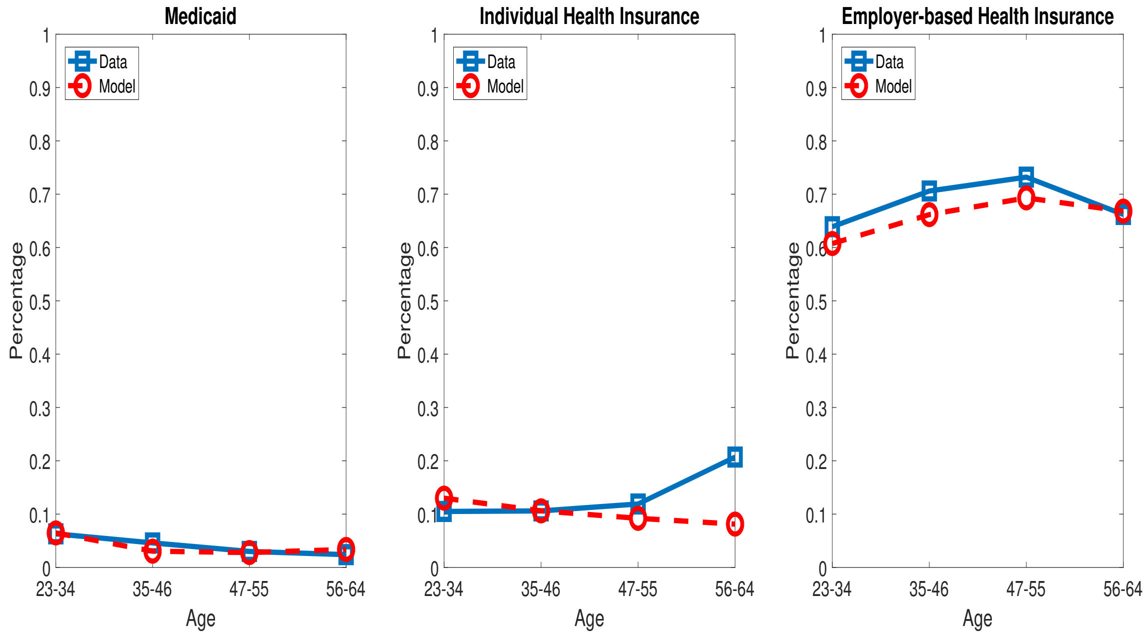


Figure 5: Age Profiles of Insurance Take-up Ratios

Figure 5 shows the age profile of take-up ratios for health insurances. These take-up ratios in the model overall similar to those in data. Before the expansion of Medicaid under the ACA, only a small portion of working-age households used Medicaid, as it was eligible only to low-income households. The model generates this feature well. Regarding individual health insurance, the model well reproduces the life-cycle profile for those aged between 23 and 55. However, the model does not match a rise in its take-up ratio for those aged between 56 and 64, because the model cannot capture early retirements. In data, those who take early retirement tend to purchase individual health insurance until reaching the Medicare-eligible age. Since all households in the model are enforced to retire at age 65, the model fails to reproduce it. The model succeeds in generating the hump-shaped age profiles in employer-based health insurance in data. These imply that the model is overall well reflecting life-cycle features on health insurance behaviors.

Cross-sectional Dimensions: Table 3 shows cross-sectional moments that are not explicitly targeted. The empirical values of moments are from previous studies and the data. The empirical values for the average ratio of debt to earnings and the average default premium are from Livshits et al. (2007). The empirical value for the fraction of debt holders is from Athreya et al. (2009). I take the value of the fraction of bankruptcy filers holding medical debts from Himmelstein et al. (2009). The moments of financial consequences generated by the model are broadly consistent with their empirical counterparts. The average debt to earnings ratio is 8 percent in data, which is smaller than that in the model, 11 percent. The average default premium is 3.2 percent, which is in the range of empirical values. I do not define medical bankruptcy, as there is no commonly accepted definition of it among economists. Rather, I compare the moment of the fraction for bankruptcy filers holding medical debts in the model to that in data. Regarding this moment, two values are reported. The first value, 0.62, means 62 percent of bankruptcy filers have unpaid-emergency medical bills.[17] This value can be considered as the minimum of the fraction of bankruptcy filers holding medical debts. The value, 0.74, indicates that 74 percent of bankruptcy filers who have a positive value of medical expenditures. Since it is not able to separate medical debt and debts for other purposes in the model, it can be regarded as the upper bound of the fraction of bankruptcy filers holding medical debts. The fraction of debt holders is 24 percent in the model, which is larger than that in data, 13 percent.

Table 3: Untargetted Cross-sectional Moments

Moment	Empirical Value	Model Value
Debt/Earnings	0.097	0.094
AVG Default Premium	$3.2\% - 4.04\%$	3.99%
Fraction of Debt Holders	0.17	0.19
Fraction of Bankruptcy Filers Holding Medical Debts	0.62	0.75
Fraction of Households with Medical Conditions	0.68	0.59
Correlation b.w. Income and ER Visits	-0.09	-0.12
Correlation b.w. Income and Medical Conditions	-0.15	-0.23

The model period is triennial . I transform triennial moments into the annual moments.

The model also matches health-related cross-sectional moments well. The below three health-related moments are from the MEPS. The fraction of households with medical conditions is 59 percent in the model, which is similar to that in data, 68 percent. The model generates the negative values of the correlation between income and emergency room visits and the correlation between income and medical conditions quantified to health shocks. It is worth mentioning that the negative correlation values are able to be reproduced owing to the model's setting for the distribution of health shocks: the likelihood of emergency and non-emergency health shocks negatively depends on health capital.

[17]It is possible to default on emergency medical bills due to the EMTALA.

4 Results

I conduct policy experiments with three healthcare reforms: the Affordable Care Act (ACA), the American healthcare Act (AHCA), and single-payer healthcare (universal healthcare). However, I cannot cover the whole components in these policies due to their complexity, because the reforms include a large number of policy components that affect a wide range of agents in the U.S. economy. For example, policies in the ACA reach the health insurance industry, households, firms, and government sectors. Here, I mainly focus on policy components related to households.

In the following section, first, for each healthcare reform, I describe policy components taken in account in counterfactual policy experiments. Next, through the policy analysis, I compare the baseline economy to an economy based on each healthcare reform, and examine the healthcare reform's health-related outcomes, macroeconomic outcomes, financial consequences and welfare implications. Next, I decompose the effects of policy components in these healthcare reforms. Of course, it is not able to entirely isolate the effect of each policy component, as one policy component interacts with other policy components in shaping the equilibrium.

4.1 Key Features of the ACA, the AHCA, and Single-payer Healthcare

The ACA: I examine the effect of following five components:

1. Medicaid Expansion
   - Expanding its eligibility up to all working-age individuals whose income is below 138 percent of Federal Poverty Level (FPL).[18]
2. Subsidy Policy for Individual Health Insurance
   - Providing progressive subsidies for the purchase of individual health insurances.
3. Individual Health Insurance Market Reforms
   - Preventing health insurance suppliers from discriminating customers based their health status and disease record.
   - Standardizing the coverage rates for individual health insurances.
4. Insurance Mandate with Penalty

[18] FPL is a measure of income level issued annually by the Department of Health and Human Services.

Table 4: Affordable Care Act Subsidies

Income Level % of FPL	Maximum Premium % of Income
133-150	3-4
150-200	4-6.3
200-250	6.3-8.05
250-300	8.05-9.5
300-400	9.5

- Enforcing those without coverage to pay a tax penalty of 2.5 percent of income with a minimum of $ 695 in 2016.

5. Additional Taxes on Top Earners
   - Additional 3.7% investment tax on individuals (family) with an income higher than $\$200,000$ ($\$250,000$).
   - Additional 0.9% labor income tax on individuals (family) with an income higher than $\$200,000$ ($\$250,000$).

The ACA is composed of two types of policy components: redistributional policies and regulatory policies. The redistributional policies aim to reallocate healthcare resources by providing public health insurances or giving subsidy for the purchase of private health insurance to low income individuals. The regulatory policies are to make economic agents follow the reforms by either imposing pecuniary penalty or enforcing laws. The Medicaid expansions and the subsidy policy for individual health insurance are redistributional, and health insurance reforms for individual health insurances and insurance mandate with penalty are regulatory.

Among the redistributional policies, the Medicaid expansion is about a public health insurance reform for low income individuals. Before the ACA, the eligibility of Medicaid for working-age individuals hugely depends on income and family structure. In addition, the criteria for the eligibility are so strict for adults. According to the MEPS between 2000 and 2010, only 4 percent of working adults use Medicaid. The ACA expands the eligibility of Medicaid up to all working-age individuals whose income is lower than 138 percent of Federal Poverty Level (FPL).[19]

The subsidy policy for individual health insurance is a redistributional policy for middle

[19] Although originally intended to apply to all states, in 2002 the U.S. Supreme Court decision made the Medicaid expansions optional for states. As a result, in 2016, 32 states out of 51 states adopt the Medicaid Expansion in the U.S.

income individuals. This policy provides those whose income is between 133 percent of FPL and 400 percent of FPL with progressive subsidies for the purchase of private health insurance. Table 4 shows the schedule for the subsidy policy by income levels. For example, if an individual whose income is between 150 percent of FPL and 200 percent wants to buy an individual health insurance, all he needs to pay is 6.3 percent to 8.05 percent of his income. The rest of the cost is covered by subsidy. As a result, individuals with different incomes face different effective prices for health insurance. Poorer households face lower prices for health insurance.

The reform of individual health insurance reform is a regulatory policy for the quality of private individual health insurances. This policy is (i) to prevent insurance companies from discriminating the insurance premium based on users information on health and disease, and (ii) to providing higher coverage of health insurances that are standardized in four types: Platinum health plan (90% of coverage rate), Gold health plan (coverage rate 80%), Silver health plan (70% of coverage rate) and Bronze health plan (60% of coverage rate). The first regulation implies that in my policy experiment, his premium of individual health insurances is independent of health status under the ACA, while it depends on health before the ACA. Under the ACA, Information on sex, age, and smoking can only be available for charging the price of individual health insurances. The second regulation implies that the ACA improves the coverage rate of individual health insurances by laws. Before the ACA, the average ratio of out-of-pocket medical expenditures to total medical expenditures is 55% in the MEPS. This regulation enforces this ratio to be at least 40%. For the policy experiment, I choose the most popular health plan: Silver health plan (70% of coverage rate).

The insurance mandate with penalty implies that in 2016, those who do not have any health insurance have to pay the maximum amount between 2.5 percent of income and 695 dollars for tax penalty. This policy targets to mitigate adverse section problems in individual health insurance markets by making individuals participate the insurance markets more.

Taxes on top earners are levied to finance the ACA.[20] The ACA imposes additional investment and labor income taxes on individuals (families) with a higher income than $\$200,000$ ($\$250,000$). However, as Pashchenko and Porapakkarm (2013) point out, a standard log-normal income process that is used in the model cannot generates the empirical

[20]The ACA also levies taxes on health insurance providers and firms selling medical devices, but these are not covered in this paper.

fraction of top-earners. To capture the progressivity of these tax schemes under the ACA, I modify the general income tax function, $T(y) = a_0\{y - (y^{-a_1} + a_2)^{-1/a_1}\} + \tau_y y$. I readjust a_0 to reach the government budget balances under the ACA, while keeping a_0 and τ_y at the level of the baseline economy.

The AHCA: Many policy components in the AHCA are similar to those in the U.S. healthcare system before the ACA. The AHCA incapacitates many policy components in the ACA such as the expansion in Medicaid, the income-dependent subsidy for the purchase of individual health insurance, the individual health insurance market reforms, the insurance mandate with a penalty and additional taxes for top earners. However, it does not mean that the AHCA is exactly the same as the healthcare system before the ACA. The AHCA has a tax credit for the purchase of health insurance.[21] I examine the effect of the following tax credits in the AHCA.

Table 5: Age-based Tax Credits of the AHCA

AGE	Tax Credit*
Under 30	$\max\{\$2,000 - 0.1 \times \max\{income - \$75,000, 0\}, 0\}$
30-39	$\max\{\$2,500 - 0.1 \times \max\{income - \$75,000, 0\}, 0\}$
40-49	$\max\{\$3,000 - 0.1 \times \max\{income - \$75,000, 0\}, 0\}$
50-59	$\max\{\$3,500 - 0.1 \times \max\{income - \$75,000, 0\}, 0\}$
60+	$\max\{\$4,000 - 0.1 \times \max\{income - \$75,000, 0\}, 0\}$

Source: https://www.kff.org/health-reform/issue-brief/how-affordable-care-act-repeal-and-replace-plans-might-shift-health-insurance-tax-credits/
and Holahan et al. (2017)
* Unit=U.S. dollar in 2020.

The amount of tax credits under the AHCA increases with age, and they are lump-sum credits unless the income is more than 75,000 U.S. dollars in 2020. Given the fact that the average income increases until the middle 50s, the tax credits are regressive with income. Even those whose income is more than 75,000 U.S. dollars in 2020, they receive tax credits that are phased out with the above formula. These features are different from the features

[21]The AHCA also includes a different type of insurance mandate: insurers can impose a one-year 30% surcharge on consumers with a lapse in coverage of more than 63 days. Since the model period is three years, I do not address this policy component in this paper.

in the subsidies of the ACA, which are progressive in income and works for individuals whose income is less than 400 percent of the FPL.

The AHCA has no specific governments financing plan, contrary to the ACA. The AHCA eliminates taxes for top earners and taxes from insurance companies. However, in the model, since the tax credits require the government to adjust its tax revenues, I assume that, in the income tax function, $T(y) = a_0\{y - (y^{-a_1} + a_2)^{-1/a_1}\} + \tau_y y$, the proportional income tax rate, τ_y is adjusted to balance the government budget. Since the AHCA eliminates taxes for top-earners, adjusting proportional tax rate is more consistent with the spirit of the AHCA.

Single-payer healthcare: Many developed and developing countries take the single-payer healthcare system. The government provides health insurance to all working-age individuals. The health insurance is funded by tax revenues. I assume that the public insurance covers 70 percent of medical expenditures. The progressive parameter, a_0, of the tax function, $T(y) = a_0\{y - (y^{-a_1} + a_2)^{-1/a_1}\} + \tau_y y$, is adjusted to balance the government budget. Adjusting a_0 is more consistent with the Sprite of single-payer health insurance, given the progressivity of this policy.

4.1.1 Results for the Policy Experiment

Health-related Outcomes: Table 6 shows health-related outcomes of the economies with healthcare reforms at the aggregate level. Column 1 shows the health-related outcomes in the baseline economy; column 2 is those in the economy with ACA; column 3 is those in the economy with the AHCA, and Column 4 is those in the economy with the single-payer economy. Compared to the baseline economy, all three healthcare reforms qualitatively bring about the same changes. The average and coefficient of variation of medical expenditure decline, the take-up ratio of health insurances increase, overall health measures improve, and the correlations between income and health measures fall. However, the three healthcare reforms have quantitively different impacts on health-related outcomes. Single-payer healthcare induces the most significant declines in the average and coefficient of variations of medical expenditures. The economy with the AHCA shows the second largest drop in the average medical expenditures, while the economy with the ACA has the second largest fall in the coefficient of medical expenditures.

Table 6: Health-Related Outcomes of the ACA, the AHCA, and Single-payer Healthcare

Moment	(1)	(2)	(3)	(4)
Medical Expenditure				
AVG Medical Expenditure*	5898	5721	5641	5556
CV of Medical Expenditures	2.42	2.4	2.4	2.35
Health Insurance				
Total Insurance Take-up Ratio	82.7%	98.5%	92%	100%
Medicaid Take-up Ratio	4.2%	14.39%	3.86%	-
IHI Take-up Ratio	11.4%	20.73%	60.96%	-
IHI Premium/AVG Income**	5.7%	7.2%	4.4%	-
EHI Take-up Ratio	67%	63.4%	27.21%	-
EHI Premium/AVG Income**	8.6%	7.03%	11.2%	-
Health Measure				
AVG Health Status	0.680	0.698	0.686	0.698
STD of Log Health Status	0.829	0.797	0.823	0.798
AVG Medical Conditions (Health Shocks)	0.349	0.342	0.346	0.343
AVG Prob of ER Visits	0.115	0.109	0.113	0.111
Corr Income and Health Measure				
Corr b.w. Income and Medical Conditions	-0.23	-0.198	-0.211	-0.188
Corr b.w. Income and ER Visits	-0.124	-0.112	-0.120	-0.112

(1) Basline; (2) ACA; (3) AHCA; (4) Single-payer

The model period is triennial . I transform triennial moments into the annual moments.

* Unit=U.S. dollar in 2000.

** It is the the average income in the baseline economy.

The insurance composition substantially varies across healthcare reforms. The ACA increases the take-up ratio of Medicaid due to the expansion in Medicaid. Also the take-up ratio of individual health insurance rises owing to the progressive subsidy for the purchase of it and insurance mandate with a tax penalty. These policy components crowd out employer-based health insurance around 5 percentage point. The premium of employer-based health insurance falls in the economy with the ACA, as the expanded Medicaid absorbs low-income and high-risky individuals. The age-based taxcredits under the AHCA increases the take-up ratio of individual insurance around 49 percentage point, while crowding out employer-based health insurance. Since it changes the composition of the pool of employer-based health insurances to be more risky, its premium rises.

The ACA has quantitatively similar impacts on health measures to single-payer healthcare. The AHCA drives as considerable improvements in health as the ACA, while the average medical expenditure is lower in the single-payer case. It means sigle-payer healthcare allocates medical expenditures across individuals in more efficient ways. Although the AHCA also reduces the average medical expenditure, it is not along with substantial improvements in health, which is a contrast to the single-payer case. The economy with the ACA shows similar results to that with the single-payer for the correlation between income and medical conditions and that between income and emergency room visits.

Macroeconomic Outcomes: Table 7 demonstrates macroeconomic outcomes in economies with the ACA, the AHCA, and single-payer healthcare. Column 1 illustrates the macroeconomic outcomes in the baseline economy; column 2 shows those in the economy with the ACA; column 3 demonstrates those in the economy with AHCA, and column 4 displays those in the economy with single-payer healthcare. , Compared to the baseline economy, all three healthcare reforms decline output. This decrease in output is driven by a fall in aggregate capital stock. To finance the health care reforms, it is required to levy taxes on incomes. This rise in income taxes declines the return for saving after taxes, which causes individuals to save less.

Table 7: Macroeconomic Variables of the ACA, the AHCA, and Single-payer Healthcare

Moment	(1)	(2)	(3)	(4)
Output	1*	0.984	0.972	0.946
Capital	2.96	2.78	2.73	2.49
Capital/Output	2.96	2.83	2.81	2.63
AVG of Non-medical Consumption	0.396	0.373	0.381	0.351
STD of log Non-medical Consumption	0.901	0.890	0.884	0.876
Total Units of Efficiency Labor	2.51	2.53	2.51	2.53
STD of log Earnings	1.30	1.27	1.28	1.27
Gini Coeff of Earnings	0.605	0.599	0.603	0.599
AVG Tax Rate	22.1%	22.8%	22.8%	25.7%
% of Progressive Tax Revenues	65%	66.2%	53%	69.9%

(1) Basline; (2) ACA; (3) AHCA; (4) Single-payer

* I normalize the output value in the benchmark model as 1.

The average non-medical consumption falls in all economies. This decline is the largest in the economy with single-payer, as their output declines are large. In addition, a decrease in consumption in the economy with the AHCA is not as large as that in the economy with the ACA. Agents in the economy with the AHCA less substitute their non-medical consumption into medical-consumption because the coverage of individual health insurances in the economy with the AHCA is smaller than that in the economy with the ACA. As the average health increases and inequality in health reduce, both the aggregate efficiency units of labor and inequality in earnings fall. The average tax rate is highest in the economy with single-payer, as all health insurances are funded by tax revenues.

Financial Consequences: Table 8 demonstrates the financial consequences of the ACA, the AHCA, and single-payer healthcare. Column (1) displays the financial consequences of the baseline economy. Column (2)-column (4) show results in general equilibrium, and column (5)-column (7) describe results in partial equilibrium. In general equilibrium economies, income taxes are adjusted to balance the government budget, and the risk-free interest rate and wage are adjusted to clear the capital and labor markets. In partial equilibrium settings, parameters in the income tax function are adjusted to balance the government budget, but the risk-free interest rate and wage are not fixed at the levels in the baseline economy. Column (2) (column (5)) demonstrates the results of the economy with the ACA in general equilibrium (partial equilibrium); column (3) (column(6)) shows those of the economy with the AHCA in general equilibrium (partial equilibrium), and column (4) (column(7)) displays those of the economy with single-payer healthcare in general equilibrium (partial equilibrium).

All healthcare reforms decrease the average bankruptcy rate and the average rate of defaults on emergency medical bills, and this decline is the largest in the economy with sigle-payer healthcare. The magnitude of decreases in the average rates of defaults on emergency room medical bills and bankruptcies is positively related to the size of reductions in the correlations between income and health risks. As can be seen in table 6, among the three healthcare reforms, the economy with single-payer healthcare generates the lowest correlations between income and emergency room visits and between income and medical conditions, the economy with the ACA follows that with single-payer healthcare and the economy with the AHCA does the that with the ACA. The size of reductions in defaults on emergency medical bills and bankruptcies follow this order. It is worth reminding that the size of mark-up is positively related to the total amount of unpaid medical bills. The mark-up of the hospital is also the lowest in the economy with single-payer healthcare, the

Table 8: Financial Consequences of the ACA, the AHCA, and Single-payer Healthcare

Moment	(1)	GE (2)	GE (3)	GE (4)	PE (5)	PE (6)	PE (7)
AVG B.K. Rate	0.92%	0.81%	0.86%	0.71%	0.64%	0.86%	0.71%
B.K. with Med Bills	0.73%	0.54%	0.68%	0.50%	0.44%	0.69%	0.5%
Default rate on ER Exp.	4.16%	3.53%	3.86%	3.15%	3.39%	3.77%	2.97%
Hospital's Mark-up	1.036	1.029	1.031	1.027	1.028	1.034	1.026
Risk-free Interest Rate	4%	4.53%	4.61%	5.38%	4%	4%	4%
AVG Default Premium	3.98%	3.35%	3.86%	2.93%	3.22%	3.93%	2.94%
AVG Borrowing Int. Rate	7.98%	7.88%	8.46%	8.21%	7.21%	7.93%	6.94%
AVG debt*	2153	2011	2120	1687	2076	2175	1811

(1) Basline; (2) ACA with GE; (3) AHCA with GE; (4) Single-payer with GE ;(5) ACA with PE; (6) AHCA with PE; (7) Single-payer with PE.

The model period is triennial . I transform triennial moments into the annual moments.

* Unit=U.S. dollar in 2000.

middle in the economy with the ACA, and the largest in the economy with the AHCA. These findings imply that a more redistributive healthcare reform tends to mitigate the correlation between income and health risks, and thereby declining overall default risks in the economy.

All healthcare reforms increase the risk-free interest rate in general equilibrium, and this increase is the largest in the economy with single-payer. an increase in the risk-free interest rate is induced by a reduction in the aggregate capital stock, as in table 7. It is required to levy additional income taxes to fund the reforms. Those added income taxes decline a return of saving after tax, which declines the supply of aggregate capital. In general equilibrium, it raises the risk-free interest rate. This general equilibrium effect is the largest in the economy with single-payer healthcare because the distortion of income tax is the largest in this economy to fund public health insurance for all working-age individuals. The general equilibrium in the economy with the AHCA is the second largest, and that with the ACA is the lowest.

The average borrowing cost varies based on healthcare reforms. The average borrowing cost is determined not only by the default premium across individuals but also by the risk-free interest rate at the aggregate level. Healthcare reforms have different impacts on the average default premium and the risk-free interest rate, respectively. On the one hand, more progressive healthcare reforms reduce the average default premium. Since the default premium increases with the overall level of default risks, more progressive healthcare reforms decrease the average default premium by providing insurances against health risks to low-income individuals. Thus, the average default premium tends to be small when healthcare reforms mitigate the correlation between income and health risks, that is shown in table 7. This decline in the overall default premium plays a role in a reduction in the average borrowing cost.

On the other hand, more progressive healthcare reforms raise the risk-free interest rate. This rise in the risk-free interest rate is related to a reduction in the aggregate capital stock. To finance healthcare reforms, it is required to levy additional income taxes. This increase in income taxes declines a return for saving after taxes, which leads to a reduction in the aggregate supply of saving. This decline in the aggregate supply of saving increases its price, the risk-free interest rate in general equilibrium. This general equilibrium effect is substantial in an economy with more progressive healthcare, as this reform tend to have more distortion in the income taxes to finance the reform. The rise in the risk-free interest rate increases the overall borrowing cost.

The average borrowing cost differs based on healthcare reforms, as the relative force between a reduction in the average default premium and an increase in the risk-free interest rate is different across healthcare reforms. The economy with the ACA in general equilibrium (column 2) has an increase in the risk-free interest rate by 0.52 percentage point, but its average default premium falls by 0.6 percentage point. Since the force of the reduction in the average default premium is stronger than that of increase in the risk-free interest rate, the overall borrowing cost declines by 0.07 percentage point, compared to the baseline economy. Although the economy with single-payer healthcare has the most significant decline in the average default premium, its average borrowing cost is higher than that in the economy with the ACA due to a substantial increase in the risk-free interest rate. For the case of the AHCA, an increase in the risk-free interest rate dominate over a reduce in the average default premium, resulting in a rise in the overall borrowing cost. As shown in column (5) - column (7), the average borrowing cost is determined only by the average default premium in partial equilibrium.

Healthcare reforms decrease the average size of debts, and this decline is the most significant in the economy with single-payer healthcare. A decline in the demand for debts is the deriving force behind a decline in overall debts, rather than an increase in the average borrowing cost. Column (5) - column (7) shows that even when the average borrowing costs in partial equilibrium are lower than the average cost in the baseline, the size of debts declines in the economy with the ACA and that with single-payer healthcare. The magnitude of a decrease in debts is positively related to reforms health insurance coverage. Medical bills are one of the important reasons for making debts. The provision of health insurance decreases the demand for debts for medical reasons. It implies that the more generous healthcare reforms, the more substantial a reduction in debts.

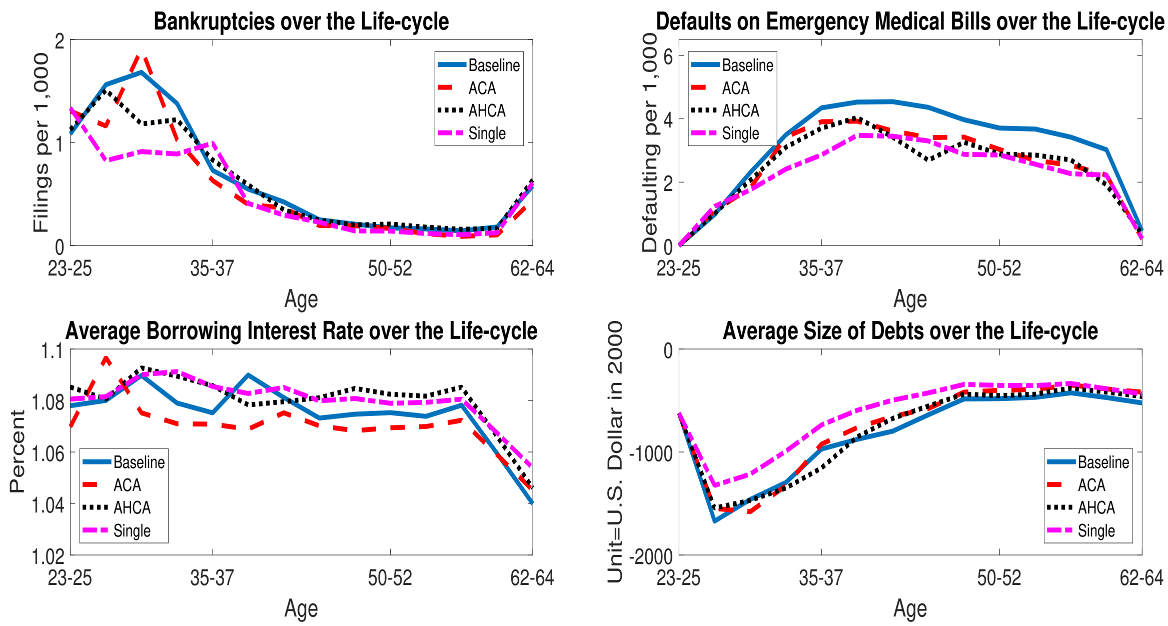


Figure 6: Financial Consequences of the Healthcare Reforms over the Life-cycle

Figure 6 demonstrates the financial consequences of the three healthcare reforms over the life-cycle. The upper left of the figure 6 shows the age profiles of bankruptcies. All of the economies show hump-shaped profiles in filing bankruptcies. For overall age groups, the baseline economy has the highest bankruptcy filings, and the economy with single-payer produces the lowest age profile of bankruptcies over the life-cycle on average. The economy with ACA and that with the AHCA are in the middle, but on average, the filings of bankruptcies in the economy with the AHCA are higher than those in the economy with the ACA. The ACA and single-payer healthcare reduce the filings of bankruptcies for those aged between 35 and 59, while the AHCA does not produce this pattern. It means that bankruptcies are reduced by healthcare reforms that provide high-quality insurances to more people.

The upper right of the figure 6 displays the age profiles of defaults on emergency medical bills. They follow an upper U-shape. The baseline economy produces the highest defaults over all age groups and the economy with single-payer healthcare. The economy with the ACA and that with the AHCA produce age profiles that are lower than that in the baseline economy but higher than that in the economy with single-payer healthcare. As bankruptcies do, defaults on emergency medical bills are reduced with healthcare reforms that provide more benefits to more people.

The lower left of the figure 6 presents the average borrowing interest rates in the four economies. The economy with the AHCA produces the highest borrowing cost over age group, and it is the lowest in the case of the ACA. As can be seen in table tab:fAHCAuni, in the economy with the ACA, the effect of a reduction in the average default premium dominates over that of an increase in the risk-free interest rate in general equilibrium. However, in other economies with healthcare reforms, the general equilibrium effect dominates over the policy effect on the default premium. Therefore, the average borrowing costs in the economy with the AHCA and that with single-payer are higher than those in the baseline economy for overall age groups.

The lower right of the figure 6 demonstrates the age profiles of the size of debts. All healthcare reforms decrease the overall size of debts, and this decline is the most substantial in the economy with single-payer healthcare. As pointed out in table 8, single-payer healthcare declines the demand for debts, as the provision of public health insurance in single-payer healthcare reduces the need for borrowing from medical reasons. The other two healthcare reforms also decrease the demand for debts for the same reason. However, this magnitude is quantitatively smaller in the case of other healthcare reforms, as either their benefit or coverage is less than that of single-payer healthcare.

Welfare: Welfare changes are measured by a Utilitarian function with the consumption equivalent variation. It calculates the percentage change in consumption in all dates and states that leaves a newborn household indifferent between the benchmark economy and an economy with one of the three healthcare reforms. Specifically, the welfare change, cev, is computed in the following way:

$$\begin{aligned}\sum_{j=1}^{J}\int_{\mathbf{s}}\beta^{j-1}u((1+cev)c_0(\mathbf{s},j),h_{c,0}(\mathbf{s},j))\mu_0(d\mathbf{s},j) \\ =\sum_{j=1}^{J}\int_{\mathbf{s}}\beta^{j-1}u(c_1(\mathbf{s},j),h_{c,1}(\mathbf{s},j))\mu_1(d\mathbf{s},j)\end{aligned} \tag{18}$$

, where c, h and μ are consumption function, health status, and the distribution of households. The subscript of these variables means where the variables come from. A subscript of 0 means that those variables are from the baseline economy, and that of 1 implies that the variables are from an economy that are compared to the baseline economy.

Consumption and health status determines welfare, as these two variables are the components of the utility function. A Higher level of each variable generates a higher level of welfare. In addition, given the concavity of the utility function, the less dispersed consumption and health status are across individuals, the more welfare improves. Using the welfare decomposition in Conesa et al. (2009), I divide the impact of each variable on welfare changes into a part that stems from its level change, and one part that captures changes in its distribution.

Table 9: Welfare Changes of the ACA, the AHCA, and Single-payer healthcare

		GE			PE		
		(1)	(2)	(3)	(4)	(5)	(6)
Change from the BM		-0.42%	-0.26%	-6.23%	+0.78%	+0.02%	+0.07%
Cons	Total	-9.69%	-3.98%	-13.4%	-3.01%	-0.594%	-6.41%
	LVL	-12.06%	-5.42%	-12.63%	-3.79%	-0.73%	-7.71%
	DIST	+2.37%	+1.44%	-0.80%	+0.77%	+0.13%	+1.31%
Health	Total	+9.27%	+3.72%	+7.20%	+3.80%	+0.61%	+6.48%
	LVL	+0.78%	+0.19%	+0.36%	+0.39%	+0.05%	+0.41%
	DIST	+8.49%	+3.54%	+6.85%	+3.44%	+0.56%	+6.07%

(1) ACA with GE; (2) AHCA with GE; (3) Single-payer with GE ;(4) ACA with PE; (5) AHCA with PE; (6) Single-payer with PE.

Table 9 shows welfare changes of the economies with the ACA, the AHCA, and single-payer healthcare. In general equilibrium, all three economies lose their welfare. Compared to the baseline economy, welfare declines by 0.42 percent in the economy with ACA. The economy with the AHCA loses welfare by 0.26 percent and the economy with single-payer health care loses welfare by 6.23 percent. While changes in the distribution of consumption and the level and distribution of health improve welfare, a drop in the level of consumption are so massive that the overall welfare declines. As in Jung and Tran (2016), welfare increases in partial equilibrium, because the fixed factor prices reduces the magnitude of a fall in the aggregate capital stock, which decreases the size of a decrease in the level of consumption.

5 Conclusion

This paper examines the financial consequences of three health care reforms: the Affordable Care Act (ACA), the American Health Care Act (AHCA), and single-payer health care. To do so, I build a life-cycle general equilibrium model where agents have an option for default on their medical bills as well as financial debts, decide to invest in health capital, and occasionally face emergency room events. Using data from the Medical Expenditure Panel Survey (MEPS), I calibrate the model based on the U.S. economy before the Affordable Care Act (ACA), by matching life-cycle and cross-sectional moments on income, bankruptcy, health insurance, medical expenditures, medical conditions, and emergency room visits. I use the model to conduct a series of counterfactual experiments regarding health care reforms.

Two main results are pronounced. First, compared to the baseline economy, all three health care reforms decrease the average bankruptcy and the average default rate on emergency medical bills. The magnitude is positively related to how much healthcare reforms mitigate the correlation between income and health risks. The size of these declines is the largest in the single-payer case, the economy with the ACA follows the economy with single-payer, and the economy with the AHCA shows the least declines in defaults on emergency medical bills and bankruptcies.

Second, the average default borrowing cost differs considerably based on reforms used. More redistributive healthcare reforms have different impacts on the default premium and the risk-free interest rate. More redistributive healthcare reforms tend to decrease the overall default premium due to the provision of health insurances to more individuals, which plays a role in a reduction in borrowing costs. Meanwhile, It is required to levy more income taxes to fund to the distributive healthcare reforms, and the distortion in taxes usually increases with the progressivity of healthcare reforms. The distorted taxes decrease the aggregate supply of capital, as it reduces a return of saving after income taxes. This decline in the aggregate capital stock increases the risk-free interest rate, which inclines the overall borrowing costs.

The average borrowing cost is determined in tensions between these two forces. The model predicts that the economy with the ACA has the lowest average borrowing cost, in which the policy effects on the average default premium are dominant over the general equilibrium. However, compared to the baseline economy, the average borrowing cost increases in the economy with the AHCA and that with single-payer healthcare, as the general equilibrium effects dominate over the policy effects on the default premium.

Regarding future research, elaborating the olds insurance choice behavior seems essential. Here, the effect of healthcare policies is not much amplified to elderly households, as health insurance policies are for working-age individuals. Given a considerable effect of Long-Term Cares on the aggregate savings, as in Kopecky and Koreshkova (2014), studying how long-term care risks and insurances interacts with financial risks will be an meaningful task. Such an analysis is deferred to future work.

References

Ales, Laurence, Roozbeh Hosseini, and Larry E Jones, "Is There" Too Much" Inequality in Health Spending Across Income Groups?," Technical Report, National Bureau of Economic Research 2012.

Arellano, Cristina, "Default risk and income fluctuations in emerging economies," *The American Economic Review*, 2008, pp. 690–712.

Athreya, Kartik B, "Default, insurance, and debt over the life-cycle," *Journal of Monetary Economics*, 2008, *55* (4), 752–774.

Athreya, Kartik, Xuan S Tam, and Eric R Young, "Unsecured credit markets are not insurance markets," *Journal of Monetary Economics*, 2009, *56* (1), 83–103.

Attanasio, Orazio, Sagiri Kitao, and Giovanni L Violante, "Financing Medicare: A general equilibrium analysis," in "Demography and the Economy," University of Chicago Press, 2010, pp. 333–366.

Carroll, Christopher D, "The method of endogenous gridpoints for solving dynamic stochastic optimization problems," *Economics letters*, 2006, *91* (3), 312–320.

Chatterjee, Satyajit, Dean Corbae, Makoto Nakajima, and José-Víctor Ríos-Rull, "A Quantitative Theory of Unsecured Consumer Credit with Risk of Default," *Econometrica*, 2007, pp. 1525–1589.

Clausen, Andrew and Carlo Strub, "A General and Intuitive Envelope Theorem," 2017.

Cole, Harold L, Soojin Kim, and Dirk Krueger, "Analyzing the effects of insuring health risks: On the trade-off between short run insurance benefits vs. long run incentive costs," Technical Report, National Bureau of Economic Research 2012.

Conesa, Juan Carlos, Sagiri Kitao, and Dirk Krueger, "Taxing capital? Not a bad idea after all!," *American Economic Review*, 2009, *99* (1), 25–48.

Currie, Janet and Brigitte C Madrian, "Health, health insurance and the labor market," *Handbook of labor economics*, 1999, *3*, 3309–3416.

Deaton, Angus, "Health, inequality, and economic development," *Journal of economic literature*, 2003, *41* (1), 113–158.

Díaz-Giménez, Javier, Andy Glover, and José-Víctor Ríos-Rull, "Facts on the distributions of earnings, income, and wealth in the United States: 2007 update," *Federal Reserve Bank of Minneapolis Quarterly Review*, 2011, *34* (1), 2–31.

Dobkin, Carlos, Amy Finkelstein, Raymond Kluender, and Matthew J Notowidigdo, "The economic consequences of hospital admissions," *American Economic Review*, 2018, *108* (2), 308–52.

Fella, Giulio, "A generalized endogenous grid method for non-smooth and non-concave problems," *Review of Economic Dynamics*, 2014, *17* (2), 329–344.

Finkelstein, Amy, Erzo FP Luttmer, and Matthew J Notowidigdo, "What good is wealth without health? The effect of health on the marginal utility of consumption," *Journal of the European Economic Association*, 2013, *11* (suppl_1), 221–258.

Franks, Peter, Marthe R Gold, and Kevin Fiscella, "Sociodemographics, self-rated health, and mortality in the US," *Social science & medicine*, 2003, *56* (12), 2505–2514.

Gouveia, Miguel and Robert P Strauss, "Effective federal individual income tax functions: An exploratory empirical analysis," *National Tax Journal*, 1994, pp. 317–339.

Gross, Tal and Matthew J Notowidigdo, "Health insurance and the consumer bankruptcy decision: Evidence from expansions of Medicaid," *Journal of Public Economics*, 2011, *95* (7), 767–778.

Grossman, Michael, "On the concept of health capital and the demand for health," *The journal of political economy*, 1972, pp. 223–255.

— , "The human capital model," *Handbook of health economics*, 2000, *1*, 347–408.

Hall, Robert E and Charles I Jones, "The Value of Life and the Rise in Health Spending," *The Quarterly Journal of Economics*, 2007, *122* (1), 39–72.

Hansen, Gary D, Minchung Hsu, and Junsang Lee, "Health insurance reform: The impact of a Medicare buy-in," *Journal of Economic Dynamics and Control*, 2014, *45*, 315–329.

Heathcote, Jonathan, Fabrizio Perri, and Giovanni L Violante, "Unequal we stand: An empirical analysis of economic inequality in the United States, 1967–2006," *Review of Economic dynamics*, 2010, *13* (1), 15–51.

Himmelstein, David U, Deborah Thorne, Elizabeth Warren, and Steffie Woolhandler, "Medical bankruptcy in the United States, 2007: results of a national study," *The American journal of medicine*, 2009, *122* (8), 741–746.

Holahan, John, Linda J Blumberg, and Erik Wengle, "Premium tax credits tied to age versus income and available premiums: differences by age, income, and geography," 2017.

Holmes, Julia S and Jennifer H Madans, "Health, United States, 2012; with special feature on emergency care," 2013.

Hu, Luojia, Robert Kaestner, Bhashkar Mazumder, Sarah Miller, and Ashley Wong, "The effect of the affordable care act Medicaid expansions on financial wellbeing," *Journal of Public Economics*, 2018.

Jang, Youngsoo and Soyoung Lee, "Generalized Endogenous Grid Method for Models with a Default Option," *Working Paper*, 2018.

Jeske, Karsten and Sagiri Kitao, "US tax policy and health insurance demand: Can a regressive policy improve welfare?," *Journal of Monetary Economics*, 2009, *56* (2), 210–221.

Jones, Melanie K, "Disability and the labour market: a review of the empirical evidence," *Journal of Economic Studies*, 2008, *35* (5), 405–424.

Jung, Juergen and Chung Tran, "Market inefficiency, insurance mandate and welfare: US health care reform 2010," *Review of Economic Dynamics*, 2016, *20*, 132–159.

Kopecky, Karen A and Tatyana Koreshkova, "The impact of medical and nursing home expenses on savings," *American Economic Journal: Macroeconomics*, 2014, *6* (3), 29–72.

Lacson, Eduardo, Jianglin Xu, Shu-Fang Lin, Sandie Guerra Dean, J Michael Lazarus, and Raymond M Hakim, "A comparison of SF-36 and SF-12 composite scores and subsequent hospitalization and mortality risks in long-term dialysis patients," *Clinical Journal of the American Society of Nephrology*, 2010, *5* (2), 252–260.

Livshits, Igor, James MacGee, and Michele Tertilt, "Consumer bankruptcy: A fresh start," *American Economic Review*, 2007, pp. 402–418.

Mahoney, Neale, "Bankruptcy as Implicit Health Insurance," *American Economic Review*, 2015, *105* (2), 710–46.

Mazumder, Bhashkar and Sarah Miller, "The effects of the Massachusetts health reform on household financial distress," *American Economic Journal: Economic Policy*, 2016, *8* (3), 284–313.

Nakajima, Makoto and Didem Tuzemen, "Health-care reform or labor market reform? A quantitative analysis of the affordable care act," 2015.

__ **and José-Víctor Ríos-Rull**, "Credit, bankruptcy, and aggregate fluctuations," Technical Report, National Bureau of Economic Research 2014.

Nardi, Mariacristina De, Eric French, and John B Jones, "Why Do the Elderly Save? The Role of Medical Expenses," *Journal of Political Economy*, 2010, *118* (1), 39–75.

Østhus, Tone Brit Hortemo, Valjbona Tiric Preljevic, Leiv Sandvik, Torbjørn Leivestad, Inger Hilde Nordhus, Toril Dammen, and Ingrid Os, "Mortality and health-related quality of life in prevalent dialysis patients: Comparison between 12-items and 36-items short-form health survey," *Health and quality of life outcomes*, 2012, *10* (1), 1.

Ozkan, Serdar, "Preventive vs. Curative Medicine: A Macroeconomic Analysis of Health Care over the Life Cycle," *Working Paper, University of Toronto*, 2014.

Pashchenko, Svetlana and Ponpoje Porapakkarm, "Quantitative analysis of health insurance reform: Separating regulation from redistribution," *Review of Economic Dynamics*, 2013, *16* (3), 383–404.

Prados, María José, "Health and earnings inequality over the life cycle: The redistributive potential of health policies," *Columbia University*, 2012.

Rumsfeld, John S, Samantha MaWhinney, Martin McCarthy Jr, A Laurie W Shroyer, Catherine B VillaNueva, Maureen O'brien, Thomas E Moritz, William G Henderson, Frederick L Grover, Gulshan K Sethi et al., "Health-related quality of life as a predictor of mortality following coronary artery bypass graft surgery," *Jama*, 1999, *281* (14), 1298–1303.

Storesletten, Kjetil, Chris I Telmer, and Amir Yaron, "Cyclical dynamics in idiosyncratic labor market risk," *Journal of Political Economy*, 2004, *112* (3), 695–717.

Sullivan, Teresa A, Elizabeth Warren, and Jay Lawrence Westbrook, *The fragile middle class: Americans in debt*, Yale University Press, 2001.

FOR ONLINE PUBLICATION

Appendix A Charges from ER Events across Income Levels

Table 10: Charges from ER Events by Income Groups

Income	Average Charges of ER Events*
0-20 pct	2443.56
20-40 pct	2436.46
40-60 pct	2249.54
60-80 pct	2307.37
80-100 pct	2325.41

Source: author's calculation based on the MEPS 2000-2011
[*] Unit = U.S. Dollar in 2000

Table 11: Charges from ER Events by Age and Income Groups

	Average Charges for ER Events*					
Income	Age 23 - 34	Age 35 - 46	Age 47 - 55	Age 56 -64	Age 65 - 76	Age 77 - 91
0-20 pct	1992.87	2222.93	2549.63	3025.09	2616.33	3154.18
20-40 pct	2094.95	2066.45	2752.9	2820.07	2902.95	2657.69
40-60 pct	2030.77	2129.41	2603.14	2625.31	2112.71	2197.29
60-80 pct	2023.42	2244.27	2394.9	2582.79	2348.57	2607.37
80-100 pct	2209.8	2051.07	2577.25	2464.83	2687.7	2284.63

Source: author's calculation based on the MEPS
[*] Unit = U.S. Dollar in 2000

Table 10 shows that differences in the average charges from ER events are small across income levels. The maximum gap is smaller than 200 dollars. Table 11 also confirms that the result is still robust after controlling age groups. Last, table 12 indicates that the correlation between the log of charges for the ER and the log of income is not statistically significant at the 10 percent level.

Table 12: Regression Result of the Log of ER Charges

	Only Income	Age and Income
log income	0.122 (0.144)	0.12(0.144)
age		0.005778 (0.004)

I run an OLS regression of the log of ER charges on the log of income and age.
The parentheses indicate p-values.

Appendix B Household Dynamic Problems

The households optimal decision problems can be represented recursively. I begin with the problems of working-age households. They start working at the initial age J_0 and continue working until age $J_r - 1$. The state of working-age households is $(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega)$ and $v \in \{G, B\}$, where a is their level of assets, i is health insurance, h is the stock of health capital, ϵ_e is emergency health shock, ϵ_n is non-emergency health shock, η is idiosyncratic shock on labor productivity and ω is the current offer status for employer-based health insurance. v is the current credit status, where G and B mean good credit and bad credit, respectively.

At the beginning of sub-period 1, emergency health shocks ϵ_e, non-emergency health shocks ϵ_n, idiosyncratic shocks on earnings η, and the employer-based health insurance offer ω, are realized. Next, individuals decide whether to default. Let $V^G(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j)$ $(V^B(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j))$ denote the value function of age $j < J_r$ agent with good (bad) credit in sub-period 1. They solve

$$V^G(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j) = \max\left\{v^{G,N}(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j), v^{G,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega, j)\right\} \tag{19}$$

$$V^B(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j) = \max\left\{v^{B,N}(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j), v^{B,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega, j)\right\} \tag{20}$$

where $v^{G,N}(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j)$ $(v^{B,N}(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j))$ is the value of non-defaulting with good credit (bad credit) and $v_j^{G,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega)$ $(v^{B,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega, j))$ is the value of defaulting with good credit (bad credit). The values of defaulting, $v^{G,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega, j)$ and $v^{B,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega, j)$, do not depend on the current assets a, as all assets and debts are eliminated with the default decision, $a = 0$.

Non-defaulters with good credit status at age $j < J_r$ in age group j_g solve

$$v^{G,N}(a,i,h,\epsilon_e,\epsilon_n,\eta,\omega,j) = \max_{\{c,\, a',\, i',\, m_n \geq 0\}} \frac{\left[\left(\lambda_u c^{\frac{v-1}{v}} + (1-\lambda_u) h_c^{\frac{v-1}{v}}\right)^{\frac{v}{v-1}}\right]^{1-\sigma}}{1-\sigma}$$
$$+ \beta \pi_{j+1|j}(h_c, j_g) \mathop{\mathbb{E}}_{\epsilon_e'|h', \epsilon_n'|h', \eta'|\eta, \omega'|\eta'} \left[V^G(a', i', h', \epsilon_e', \epsilon_n', \eta', \omega', j+1)\right] \tag{21}$$

such that

$$c + q(a', i', h'; j, \eta)a' + p_{i'}(h_c, j_g)$$
$$\leq (1 - \tau_{ss} - \tau_{med}) w \bar{\omega}_j h_c \eta + a - (1 - q_i)(m_n + m_e(\epsilon_e)) - T(y) + \kappa$$

$$h' = h_c + \varphi_{j_g} m_n^{\psi_{jg}} = (1-\epsilon_n)(1-\epsilon_e)h + \varphi_{j_g} m_n^{\psi_{jg}}$$
$$i \in \{NHI, MCD, IHI, EHI\}$$
$$i' \in \begin{cases} \{NHI, MCD, IHI, EHI\} & \text{if } y \leq \bar{y} \text{ \& } \omega = 1 \\ \{NHI, MCD, IHI\} & \text{if } y \leq \bar{y} \text{ \& } \omega = 0 \\ \{NHI, IHI, EHI\} & \text{if } y > \bar{y} \text{ \& } \omega = 1 \\ \{NHI, IHI\} & \text{if } y > \bar{y} \text{ \& } \omega = 0. \end{cases}$$
$$y = w \omega_j h_c \eta + (\frac{1}{q^{rf}} - 1) a \cdot \mathbb{1}_{a>0}$$

,where c is consumption, a' is asset holdings in the next period, i' is the purchase of health insurance for next period, m_n is non-emergency medical expenditure, h_c is the current health status and β is the discount rate. $p_{i'}(h_c, j_g)$ is the rate of surviving up to age $j+1$ condition on surviving up to age j with the current status of health h_c in age group j_g. $\mathbb{E}_{\epsilon_e', \epsilon_n', \eta | \eta', \omega'}$ is, conditional on the current idiosyncratic labor productivity η, the expectation of (non-) emergency health shocks (ϵ_n') ϵ_e' in the next period, idiosyncratic shocks on labor productivity η' in the next period and the offer probability of employer-based health insurance ω' in the next period. $q(a', i', h'; j, \eta)$ is the discount rate of loan for households with future endogenous state, (a', i', h'), conditional on the current idiosyncratic labor productivity, η and age j, and $p_{i'}(h_c, j_g)$ is the premium of health insurance i' for the next period given the current health status h_c and age group j_g. τ_{ss} and τ_{med} are payroll taxes for Social Security and Medicare, respectively. w is the market equilibrium wage, $\bar{\omega}_j$ is age-deterministic labor productivity, η is idiosyncratic shock on labor productivity, q_i is the coverage rate of health insurance i, $m_e(\epsilon_e)$ is emergency medical expense, $T(\cdot)$ is income tax, y is total income and κ is accidental bequest. NHI means no health insurance, MCD is

Medicaid, IHI is private individual health insurance, EHI is employer-based health insurance, $\bar{y}$ is the threshold for Medicaid eligibility, ω is the current offer status for employer-based health insurance, q^{rf} is the discount rate of the risk-free bond and $\mathbb{1}$ is the indicator function for savings. Thus, $(\frac{1}{q^{rf}} - 1)a$ means capital income.

It is worth noting that the expectation is taken to emergency and non-emergency health shocks conditional on health capital $h^{'}$ for next period,$\epsilon_e^{'}|h^{'}$ and $\epsilon_n^{'}|h^{'}$ as the distributions of these health shocks in the next period are determined by health capital $h^{'}$ for next period. In addition, the probability of the offer for employer-based health insurance is condition on idiosyncratic shocks on earnings η in the next period, as the offer rate increases with labor productivity level, $\omega^{'}|\eta^{'}$.

Non-defaulters with good credit status have an endowment from their labor income $w\bar{\omega}_j h_c \eta$, their current assets a and accidental bequest κ. Then, these households access financial intermediary to either borrow $(a^{'} < 0)$ at prices that reflect their default risk or save $(a^{'} > 0)$. Afterward, they make decisions on consumption c, the purchase of health insurance $i^{'}$, and non-emergency medical expenditures m_n. In turn, non-defaulters with good credit status pay a health insurance premium $p_{i'}(h_c, j_g)$, an out-of-pocket medical expenditures $(1 - q_i)(m_n + m_e(\epsilon_e))$, payroll taxes for Social Security and Medicaid $(\tau_{ss} + \tau_{med})w\bar{\omega}_j h_c \eta$, and income tax $T(y)$ for income $y = w\omega_j h_c \eta + (\frac{1}{q^{rf}} - 1)a \cdot \mathbb{1}_{a>0}$. They preserve good credit status until the next period.

Defaulting households with good credit status at age $j < J_r$ in age group j_g solve

$$v^{G,D}(i, h, \epsilon_e, \epsilon_n, \eta, \omega, j) = \max_{\{c,\, i^{'},\, m_n \geq 0\}} \frac{\left[\left(\lambda_u c^{\frac{v-1}{v}} + (1-\lambda_u) h_c^{\frac{v-1}{v}}\right)^{\frac{v}{v-1}}\right]^{1-\sigma}}{1-\sigma}$$
$$+ \beta \pi_{j+1|j}(h_c, j_g) \mathop{\mathbb{E}}_{\epsilon_e^{'}|h^{'}, \epsilon_n^{'}|h^{'}, \eta^{'}|\eta, \omega^{'}|\eta^{'}} \left[V^B(0, i^{'}, h^{'}, \epsilon_e^{'}, \epsilon_n^{'}, \eta^{'}, \eta^{'}, \omega^{'}, j+1)\right] \tag{22}$$

such that

$$c + p_{i^{'}}(h_c, j_g) = (1 - \tau_{ss} - \tau_{med}) w \bar{\omega}_j h_c \eta - (1 - q_i) m_n - T(y) + \kappa$$

$$h_c = (1 - \epsilon_n)(1 - \epsilon_e) h$$
$$h^{'} = h_c + \varphi_{j_g} m_n^{\psi_{j_g}} = (1 - \epsilon_n)(1 - \epsilon_e) h + \varphi_{j_g} m_n^{\psi_{j_g}}$$
$$i \in \{NHI, MCD, IHI, EHI\}$$
$$i^{'} \in \begin{cases} \{NHI, MCD, IHI, EHI\} & \text{if } y \leq \bar{y} \;\&\; \omega = 1 \\ \{NHI, MCD, IHI\} & \text{if } y \leq \bar{y} \;\&\; \omega = 0 \\ \{NHI, IHI, EHI\} & \text{if } y > \bar{y} \;\&\; \omega = 1 \\ \{NHI, IHI\} & \text{if } y > \bar{y} \;\&\; \omega = 0. \end{cases}$$
$$y = w \omega_j h_c \eta + \left(\frac{1}{q^{rf}} - 1\right) a \cdot \mathbb{1}_{a>0}.$$

On their budget constraint, debts from the financial intermediaries, a, and emergency medical expenditures, $m_e(\epsilon_e)$ do not appear, as these individuals default on these two types of unsecured debts. Defaulters can determine the level of consumption, c, the purchase of health insurance for next period, $i^{'}$, and non-emergency medical expenditure, m_n, while they can neither save nor dissave in this period. In turn, they pay a health insurance premium $p_{i^{'}}(h_c, j_g)$, an out-of-pocket medical expenditures $(1 - q_i)m_n$, payroll taxes for Social Security and Medicaid $(\tau_{ss} + \tau_{med}) w \bar{\omega}_j h_c \eta$, and income tax $T(y)$ for their labor income $y = w \omega_j h_c \eta$.

Non-defaulters with bad credit status at age $j < J_r$ in age group j_g solve

$$
\begin{aligned}
v^{B,N}(a,i,h,\epsilon_e,\epsilon_n,\eta,\omega,j) = & \max_{\{c,\, a' \geq 0,\, i', m_n \geq 0\}} \frac{\left[\left(\lambda_u c^{\frac{v-1}{v}} + (1-\lambda_u) h_c^{\frac{v-1}{v}}\right)^{\frac{v}{v-1}}\right]^{1-\sigma}}{1-\sigma} \qquad (23) \\
& + \beta \pi_{j+1|j}(h_c, j_g) \underset{\epsilon_e'|h', \epsilon_n'|h', \eta'|\eta, \omega'|\eta'}{\mathbb{E}} \Big[\lambda V^G(a', i', h', \epsilon_e', \epsilon_n', \eta', \omega', j+1) \\
& + (1-\lambda) V^B(a', i', h', \epsilon_e', \epsilon_n', \eta', \omega', j+1)\Big] \\
& \text{such that} \\
& c + q^{rf} a' + p_{i'}(h_c, j_g) \\
& \leq (1 - \tau_{ss} - \tau_{med})(1-\chi) w \bar{\omega}_j h_c \eta + a - (1-q_i)(m_n + m_e(\epsilon_e)) - T(y) + \kappa \\
& \\
& h_c = (1-\epsilon_n)(1-\epsilon_e) h \\
& h' = h_c + \varphi_{j_g} m_n^{\psi_{j_g}} = (1-\epsilon_n)(1-\epsilon_e) h + \varphi_{j_g} m_n^{\psi_{j_g}} \\
& i \in \{NHI, MCD, IHI, EHI\} \\
& i' \in \begin{cases} \{NHI, MCD, IHI, EHI\} & \text{if } y \leq \bar{y} \ \&\ \omega = 1 \\ \{NHI, MCD, IHI\} & \text{if } y \leq \bar{y} \ \&\ \omega = 0 \\ \{NHI, IHI, EHI\} & \text{if } y > \bar{y} \ \&\ \omega = 1 \\ \{NHI, IHI\} & \text{if } y > \bar{y} \ \&\ \omega = 0. \end{cases} \\
& y = w \omega_j h_c \eta + (\frac{1}{q^{rf}} - 1) a \cdot \mathbb{1}_{a>0}
\end{aligned}
$$

, where λ is the probability of recovering their credit status to be good, and $\chi w \bar{\omega}_j h_c \eta$ is the pecuniary cost of staying with bad credit status. Although the problem of non-defaulters with bad credit is similar to that of non-defaulters with good credit, there are three differences between two problems. First, non-defaulters with bad credit cannot borrow but save, $a' \geq 0$. Second, they need to pay the pecuniary cost for their bad credit status as much as a fraction χ of earnings, $w \bar{\omega}_j h_c \eta$. Last, the credit status in the next period is not deterministic. With a probability of λ, the credit status of non-defaulters with bad credit changes from bad credit to good credit, and they staying with bad credit with a probability of $1 - \lambda$. This process reflects the exclusion penalty in Chapter 7 Bankruptcy of 10 years in the US.

Defaulters with bad credit status at age $j < J_r$ in age group j_g solve

$$v^{B,D}(i,h,\epsilon_e,\epsilon_n,\eta,\omega,j) = \max_{\{c,\, i',\, m_n \geq 0\}} \frac{\left[\left(\lambda_u c^{\frac{v-1}{v}} + (1-\lambda_u) h_c^{\frac{v-1}{v}}\right)^{\frac{v}{v-1}}\right]^{1-\sigma}}{1-\sigma}$$
$$+ \beta \pi_{j+1|j}(h_c, j_g) \mathop{\mathbb{E}}_{\epsilon_e'|h',\epsilon_n'|h',\eta'|\eta,\omega'|\eta'} \left[V^B(0, i', h', \epsilon_e', \epsilon_n', \eta', \omega', j+1)\right] \tag{24}$$

such that

$$c + p_{i'}(h_c, j_g) = (1-\tau_{ss}-\tau_{med})(1-\chi) w \bar{\omega}_j h_c \eta - (1-q_i) m_n - T(y) + \kappa$$

$$h_c = (1-\epsilon_n)(1-\epsilon_e) h$$
$$h' = h_c + \varphi_{j_g} m_n^{\psi_{j_g}} = (1-\epsilon_n)(1-\epsilon_e) h + \varphi_{j_g} m_n^{\psi_{j_g}}$$
$$i \in \{NHI, MCD, IHI, EHI\}$$
$$i' \in \begin{cases} \{NHI, MCD, IHI, EHI\} & \text{if } y \leq \bar{y} \text{ \& } \omega = 1 \\ \{NHI, MCD, IHI\} & \text{if } y \leq \bar{y} \text{ \& } \omega = 0 \\ \{NHI, IHI, EHI\} & \text{if } y > \bar{y} \text{ \& } \omega = 1 \\ \{NHI, IHI\} & \text{if } y > \bar{y} \text{ \& } \omega = 0. \end{cases}$$
$$y = w \omega_j h_c \eta + (\frac{1}{q^{rf}} - 1) a \cdot \mathbb{1}_{a>0}.$$

The problem of defaulters with bad credit has two differences compared to those with good credit. First, defaulters with bad credit have to pay the pecuniary cost of staying bad credit as much as a fraction χ of their earnings, $w\bar{\omega}_j h_c$. Second, they default only on emergency medical expenses. For defaulters with bad credit, their previous status is either non-defaulter with bad credit or defaulters with good credit. In both statuses, individuals cannot make any loan. Thus, all of the defaults are on emergency medical expenses.

Retired households with good credit status at age $J_r \leq j \leq \bar{J}$ in age group j_g solve

$$V^{G,r}(a,h,\epsilon_e,\epsilon_n,j) = \max_{\{c,\, a' \geq \underline{\text{a}},\, m_n \geq 0\}} \frac{\left[\left(\lambda_u c^{\frac{v-1}{v}} + (1-\lambda_u) h_c^{\frac{v-1}{v}}\right)^{\frac{v}{v-1}}\right]^{1-\sigma}}{1-\sigma} \tag{25}$$
$$+ \beta \pi_{j+1|j}(h_c, j_g) \mathop{\mathbb{E}}_{\epsilon_e'|h', \epsilon_n'|h'} \left[V^{G,r}(a', h', \epsilon_e', \epsilon_n', j+1)\right]$$

such that

$$c + q^{rf} a' + p_{med} \leq ss + a - (1-q_{med})(m_n + m_e(\epsilon_e)) - T(y) + \kappa$$
$$h' = h_c + \varphi_{j_g} m_n^{\psi_{j_g}} = (1-\epsilon_n)(1-\epsilon_e)h + \varphi_{j_g} m_n^{\psi_{j_g}}$$
$$y = ss + (\frac{1}{q^{rf}} - 1) a \cdot \mathbb{1}_{a>0}$$

where $\underline{\text{a}}$ is the natural borrowing constraint for retired households, ss is Social Security benefit, p_{med} is the Medicare premium and q_{med} is the Medicare coverage rate. Retired households with good credit status can save assets and borrow up to their natural borrowing limit a. I assume that retired households do not access private health insurance markets. Retired households do not have labor income, but receive Social security benefit, ss, in each period. Thus, they pay income tax based on Social Security benefit ss and capital income $(\frac{1}{q^{rf}} - 1)a \cdot \mathbb{1}_{a>0}$. Retired households do not pay payroll taxes, as they do have labor income.

Retired households with bad credit status at age $J_r \leq j \leq \bar{J}$ in age group j_g solve

$$V^{B,r}(a,h,\epsilon_e,\epsilon_n,j) = \max_{\{c,\, a' \geq 0,\, m_n \geq 0\}} \frac{\left[\left(\lambda_u c^{\frac{v-1}{v}} + (1-\lambda_u) h_c^{\frac{v-1}{v}}\right)^{\frac{v}{v-1}}\right]^{1-\sigma}}{1-\sigma} \tag{26}$$
$$+ \beta \pi_{j+1|j}(h_c, j_g) \mathop{\mathbb{E}}_{\epsilon_e'|h', \epsilon_n'|h'} \Big[\lambda V^{G,r}(a', h', \epsilon_e', \epsilon_n', j+1)$$
$$+ (1-\lambda) V^{B,r}(a', h', \epsilon_e', \epsilon_n', j+1)\Big]$$

such that

$$c + q^{rf} a' + p_{med} \leq ss + a - (1-q_{med})(m_n + m_e(\epsilon_e)) - T(y) + \kappa$$
$$h' = h_c + \varphi_{j_g} m_n^{\psi_{j_g}} = (1-\epsilon_n)(1-\epsilon_e)h + \varphi_{j_g} m_n^{\psi_{j_g}}$$
$$y = ss + (\frac{1}{q^{rf}} - 1) a \cdot \mathbb{1}_{a>0}.$$

Contrary to retired households with good credit, they cannot borrow.[22] Their credit status is ran-

[22]Since retired households have no option to default, the budget set could be empty if emergency medical expenses are too large. But, it does not happen in the model. The amount of Social Security benefit in this model is fair to all of the retired households. It is large enough to cover the largest emergency medical expense here.

domly determined in the next period. With a probability λ, their credit status changes to good credit status.

Appendix C Proof of proposition 2.7.1

Clausen and Strub (2017) introduce an envelope theorem to prove that First Order Conditions are necessary conditions for the global solution. They show that the envelop theorem is applicable to default models where income shocks are iid. I extend this to solve my model with persistent idiosyncratic shock. To use their envelope theorem, it is necessary to introduce the following definition.

Definition C.0.1. We say that $F : C \to \mathbb{R}$ is **differentiably sandwiched** between the lower and upper support functions $L, U : C \to \mathbb{R}$ at $\bar{c} \in C$ if

1. L is a differentiable lower support function of F at $\bar{c}$,i.e L is differentiable, $L(c) \leq F(c)$ for all $c \in C$, and $L(\bar{c}) = F(\bar{c})$.
2. U is a differentiable upper support function of F at $\bar{c}$,i.e U is differentiable, $U(c) \geq F(c)$ for all $c \in C$, and $U(\bar{c}) = F(\bar{c})$.

Let us begin with the FOC (17): For any $a^{'} > a_{rbl}(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$

$$\frac{\partial q(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta)a^{'}}{\partial a^{'}} \frac{\partial u(c, (1-\epsilon_e)(1-\epsilon_n)\bar{h})}{\partial c} = \frac{\partial W^G(a^{'}, \bar{i}^{'}, \bar{h}^{'}, \eta, j+1)}{\partial a^{'}}.$$

Lemma 2 (Maximum Lemma) and Lemma 3 (Reverse Calculus) in Clausen and Strub (2017) tell us that if each constituent function (q, u, W^G) of the FOC (17) has a differential lower support function at a point $a^{'}$, $q \times u$ and W^G are differentiable at $a^{'}$ and the FOC (17) is a necessary condition for the global solution.

Formally, **the proof of proposition 2.7.1** is as follows:

Proof. $u(\cdot, (1-\epsilon_e)(1-\epsilon_n)\bar{h})$ has trivially a differentiable lower support function, as itself is differentiable by the assumption. By lemma C.1 and lemma C.2, the discount rate of loan $q(\cdot, \bar{i}^{'}, \bar{h}^{'}; j, \eta)$ and the expected value function $W^G(\cdot, \bar{i}^{'}, \bar{h}^{'}, \eta, j+1)$ have a differentiable lower support function. That implies that each $u(\cdot, (1-\epsilon_e)(1-\epsilon_n)\bar{h})$, $q(\cdot, \bar{i}^{'}, \bar{h}^{'}; j, \eta)$ and $W^G(\cdot, \bar{i}^{'}, \bar{h}^{'}, \eta, j+1)$ has a differentiable lower support function. Lemma 3 (Reverse Calculus) in Clausen and Strub (2017) implies that the FOC (17) exists and holds. □

Lemma C.1. *Let a state $(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$ be given. Let $a_{rbl}(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$ be the risk borrowing limit (credit limit) of $q(\cdot, \bar{i}^{'}, \bar{h}^{'}; j, \eta)$. For all $a^{'} > a_{rbl}(\bar{i}^{'}, \bar{h}^{'}; j, \eta)$, the discount rate of loan $q(\cdot, \bar{i}^{'}, \bar{h}^{'}; j, \eta)$ has a differentiable lower support function.*

Proof. Case1: For any $a \geq 0$, $q(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta) = \frac{1}{1+r^{rf}}$, and there by $\frac{\partial q(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta)a^{'}}{\partial a^{'}} = 0$. Thus, $q(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta)$ itself is a differentiable lower support function.

Case2: For any $a_{rbl}(\bar{i}', \bar{h}'; j, \eta) < a' < 0$, $q(a', \bar{i}', \bar{h}'; j, \eta) = \frac{1-d(a',\bar{i}',\bar{h}';j,\eta)}{1+r^{rf}}$. It implies that finding a lower differentiable support function of $q(a', \bar{i}', \bar{h}'; j, \eta)$ is equivalent to doing a upper differentiable support function of
$d(a', \bar{i}', \bar{h}'; j, \eta) = \sum_{\epsilon'_n, \epsilon'_e, \eta', \omega'} \pi_{\epsilon'_e|h'} \pi_{\epsilon'_n|h'} \pi_{\eta'|\eta} \pi_{\omega'|\eta'} \mathbb{1}_{\{v^{G,N}(a', \mathbf{s_1'}, \eta', j+1) \le v^{G,D}(\mathbf{s_1'}, \eta', j+1)\}}$
, where $\mathbf{s}_1' = (\bar{i}', \bar{h}', \epsilon_e', \epsilon_n', \omega')$. Let us transform $\pi_{\eta'|\eta}$ to a continuous PDF $f(\eta'|\eta)$. Given state $\mathbf{s}_1'$, let us denote $\delta(a', \eta; \mathbf{s_1'}) = \pi_{\epsilon'_\mathbf{e}|\mathbf{h}'} \pi_{\epsilon'_\mathbf{n}|\mathbf{h}'} \int \mathbb{1}_{\{\mathbf{v^{G,N}(a', s_1', \eta', j+1)} \le \mathbf{v^{G,D}(s_1', \eta', j+1)}\}} \pi_{\omega'|\eta'} \mathbf{f}(\eta'|\eta)\mathbf{d}\eta'$. Since $a' > a_{rbl}(\bar{i}', \bar{h}'; j, \eta)$, $\{\eta' : v^{G,N}(a', \mathbf{s_1'}, \eta', j+1) \le v^{G,D}(\mathbf{s_1'}, \eta', j+1)\}$ is non-empty. Theorem 3 (The Maximal Default Set Is a Closed Interval) and Theorem 4 (Maximal Default Set Expands with Indebtedness) in Chatterjee et al. (2007) imply that for any $a' > a_{rbl}(\bar{i}', \bar{h}'; j, \eta)$ and for each state $(\mathbf{s}_1', \eta', j+1)$, there are two points $\eta_1'(a'; \mathbf{s}_1', j+1)$ and $\eta_2'(a'; \mathbf{s}_1', j+1)$ such that (i) $\{\eta' : v^{G,N}(a', \mathbf{s_1'}, \eta', j+1) \le v^{G,D}(\mathbf{s_1'}, \eta', j+1)\} = [\eta_1'(a'; \mathbf{s}_1', j+1), \eta_2'(a'; \mathbf{s}_1', j+1)]$ and (ii) for any $a' < a''$, $[\eta_1'(a'; \mathbf{s}_1', j+1), \eta_2'(a'; \mathbf{s}_1', j+1)] \subset [\eta_1'(a''; \mathbf{s}_1', j+1), \eta_2'(a''; \mathbf{s}_1', j+1)]$. The first property means
$\int_{\{\eta': v^{G,N}(a', \mathbf{s_1'}, \eta', j+1) \le v^{G,D}(\mathbf{s_1'}, \eta', j+1)\}} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta' = \int_{\eta' \in [\eta_1'(a'; \mathbf{s}_1', j+1), \eta_2'(a'; \mathbf{s}_1', j+1)]} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$
, and the second property implies that $\eta_1'(a'; \mathbf{s}_1', j+1)$ increases with a' and $\eta_2'(a'; \mathbf{s}_1', j+1)$ decreases with a'.

Since $\int_{\eta' \in [\eta_1'(a'; \mathbf{s}_1', j+1), \eta_2'(a'; \mathbf{s}_1', j+1)]} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$
$= \int_{-\infty}^{\eta_2'(a'; \mathbf{s}_1', j+1)} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta' - \int_{-\infty}^{\eta_1'(a'; \mathbf{s}_1', j+1)} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$, if there is an upper differentiable support of $\int_{-\infty}^{\eta_2'(a'; \mathbf{s}_1', j+1)} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$ and an lower differentiable support of
$\int_{-\infty}^{\eta_1'(a'; \mathbf{s}_1', j+1)} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$, $\delta(a', \eta; \mathbf{s_1'}) = \int_{\eta' \in [\eta_1'(\mathbf{a}'; \mathbf{s_1'}, \mathbf{j+1}), \eta_2'(\mathbf{a}'; \mathbf{s_1'}, \mathbf{j+1})]} \pi_{\omega'|\eta'} \mathbf{f}(\eta'|\eta) \mathbf{d}\eta'$ has a differentiable lower support. Without loss of generality, I will prove the existence of a differentiable upper support of
$\int_{-\infty}^{\eta_2'(a'; \mathbf{s}_1', j+1)} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$.

Claim: $\int_{-\infty}^{\eta_2'(a'; \mathbf{s}_1', j+1)} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$ has an upper differentiable support.

Proof of the claim: Finding an upper support function of $\int_{-\infty}^{\eta_2'(a'; \mathbf{s}_1', j+1)} \pi_{\omega'|\eta'} f(\eta'|\eta) d\eta'$ is equivalent to searching for an upper support function of $\eta_2'(a'; \mathbf{s}_1', j+1)$. I am going to use the implicit function theorem to find an upper differentiable support. Take any $\hat{a}' > a_{rbl}(\bar{i}', \bar{h}'; j, \eta)$ and $\eta' \in (\eta_1'(\hat{a}'; \mathbf{s}_1', j+1), \eta_2'(\hat{a}'; \mathbf{s}_1', j+1))$. Pick any $\epsilon_1 < \eta_2'(\hat{a}'; \mathbf{s}_1', j+1) - \eta_1'(\hat{a}'; \mathbf{s}_1', j+1)$. Consider a case that for a realized value $(a', \eta') \in B((\hat{a}', \eta_2'(a'; \mathbf{s}_1', j+1)), \epsilon)$, a household anticipates state $(a', \eta') = (a', \eta_2'(a'; \mathbf{s}_1', j+1))$. In other words, the household correctly recognizes a' but incorrectly acknowledges η'. Then, in the period after the next period, the decision rule for asset holdings is $a'' = g_a(a', \eta_2'(a'; \mathbf{s}_1', j+1)$. Define this borrower's net value function $L(a', \eta'; \hat{a}')$ on

$B((a^{'},\eta_2^{'}(a^{'};\mathbf{s}_1^{'},j+1)),\epsilon)$ in the following way:

$$L(a^{'},\eta^{'};\hat{a}^{'}) = u\Big(w\bar{\omega}_j h_c\eta^{'} + a^{'} - (1-q_i)(m_n^{'} + m_e(\epsilon_e^{'})) \tag{27}$$
$$-T(y^{'}) + \kappa^{'} - q(g_a(a^{'},\eta_2^{'}(a^{'}i^{''},h^{''};\eta_2^{'}(a^{'};\mathbf{s}_1^{'},j+1),j+1)g_a(a^{'}i^{''},h^{''},\eta_2^{'}(a^{'};\mathbf{s}_1^{'},j+1),j+1) - p_{i^{''}},h_c^{'}\Big)$$
$$-u\Big(w\bar{\omega}_j h_c\eta^{'} - (1-q_i)m_n^{'} - T(y^{'}) + \kappa^{'} - p_{i^{''}},h_c^{'}\Big)$$
$$+\beta\pi_{j+2|j+1}(h_c^{'},j_g)\mathop{\mathbb{E}}_{\epsilon_e^{''}|h^{''},\epsilon_n^{''}|h^{''},\eta^{''}|\eta_2^{'}(a^{'}i^{''},h^{''}),\omega^{''}|\eta^{''}}\Bigg[\Big[V^G(g_a(a^{'},\eta_2^{'}(a^{'}i^{''},h^{''}),\eta_2^{'}(a^{'};\mathbf{s}_1^{'},j+1)),i^{''},h^{''},\epsilon_e^{''},\epsilon_n^{''},\eta^{''},\omega^{''},j+2)\Big]$$
$$-\Big[V^B(0,\eta_2^{'}(a^{'};\mathbf{s}_1^{'},j+1)),i^{''},h^{''},\epsilon_e^{''},\epsilon_n^{''},\eta^{''},\omega^{''},j+2)\Big]\Bigg]$$

Note that the value function is continuous and differentiable on $B\left((\hat{a}^{'},\eta_2^{'}(\hat{a}^{'};\mathbf{s}_1^{'},j+1)),\epsilon\right)$, as the utility function u is differentiable. Also, this value function is an implicit function for $a^{'}$ and $\eta^{'}$, and $L(\hat{a}^{'},\eta_2^{'}(\hat{a}^{'};\mathbf{s}_1^{'},j+1));\hat{a}^{'})=0$. The value function is differentiable with respect to $\eta^{'}$ and its value is non-zero (positive). Thus, the implicit function theorem implies that there is an open neighborhood U of $\hat{a}^{'}$ and an open neighborhood V of $\eta_2^{'}(\hat{a}^{'};\mathbf{s}_1^{'},j+1))$ such that $\bar{\eta}^{'}=\bar{\eta}^{'}(a^{'},\hat{a}^{'})$ satisfies

$$L(a^{'},\bar{\eta}^{'}(a^{'},\hat{a}^{'});\hat{a}^{'})=0$$

, where $\bar{\eta}^{'}\in V$ and $a^{'}\in U$. Since this household overvalues repaying debt, $\bar{\eta}^{'}(\cdot,\hat{a}^{'})$ is an upper support of $\eta_2^{'}(\cdot;\mathbf{s}_1^{'},j+1)$ at $\hat{a}^{'}$. Furthermore, the implicit function theorem implies that $\bar{\eta}^{'}(\cdot,\hat{a}^{'})$ is differentiable on U. Thus, $\bar{\eta}^{'}(\cdot,\hat{a}^{'})$ is an upper differentiable support function of $\eta_2^{'}(\cdot;\mathbf{s}_1^{'},j+1)$ at $\hat{a}^{'}$. Since the statement holds for all $a^{'}>a_{rbl}(\bar{i}^{'},\bar{h}^{'};j,\eta)$, $\eta_2^{'}(a^{'};\mathbf{s}_1^{'},j+1)$ has an upper differentiable upper support for all $a^{'}>a_{rbl}(\bar{i}^{'},\bar{h}^{'};j,\eta)$. Therefore, the claim is proven. Q.E.D.

Since $\int_{-\infty}^{\eta_2^{'}(a^{'};\mathbf{s}_1^{'},j+1)}\pi_{\omega^{'}|\eta^{'}}f(\eta^{'}|\eta)d\eta^{'}$ has an upper differentiable support function,
$d(a^{'},\bar{i}^{'},\bar{h}^{'};j,\eta)=\sum_{\epsilon_n^{'},\epsilon_e^{'},\eta^{'},\omega^{'}}\pi_{\epsilon_e^{'}|h^{'}}\pi_{\epsilon_n^{'}|h^{'}}\int_{-\infty}^{\eta_2^{'}(a^{'};\mathbf{s}_1^{'},j+1)}\pi_{\omega^{'}|\eta^{'}}f(\eta^{'}|\eta)d\eta^{'}$ has an upper differentiable support function. □

Lemma C.2. *Let a state $(\bar{i}^{'},\bar{h}^{'};j,\eta)$ be given. Let $a_{rbl}(\bar{i}^{'},\bar{h}^{'};j,\eta)$ be the risk borrowing limit (credit limit) of $q(\cdot,\bar{i}^{'},\bar{h}^{'};j,\eta)$. For all $a^{'}>a_{rbl}(\bar{i}^{'},\bar{h}^{'};j,\eta)$, the expected value function $W^G(\cdot,\bar{i}^{'},\bar{h}^{'};\eta,j+1)$ has a differentiable lower support function.*

Proof. To ease notation, let us denote $\mathbf{s}_1^{'}=(\bar{i}^{'},\bar{h}^{'},\epsilon_e,\epsilon_n,\eta^{'},\omega^{'})$
(i) Case 1: $\bar{a}^{'}>0$.
In this case, the discount rate of loan becomes q^{rf}. We can use the standard technique of Benveniste and Scheinkman's theorem. Consider a case that for a realized value $(a^{'},\eta^{'})$, a household takes $a^{''}=g_a(\bar{a}^{'},\mathbf{s}_1^{'},j+1)$ for all $a^{'}$ and $\eta^{'}$. Let us define this agent's net value function $L(a^{'},\eta^{'};\bar{a}^{'})$ in

the following way:

$$L^0(a^{'},\eta^{'};\bar{a}^{'},\mathbf{s}_1^{'}) = u\Big(w\bar{\omega}_j h_c \eta^{'} + a^{'} - (1-q_i)(m_n^{'} + m_e(\epsilon_e^{'})) - T(y^{'}) + \kappa^{'} - q^{rf} g_a(\bar{a}^{'},\mathbf{s}_1^{'},j+1) - p_{i''}, h_c^{'}\Big) \tag{28}$$

$$+\beta\pi_{j+2|j+1}(h_c^{'},j_g) \mathop{\mathbb{E}}_{\epsilon_e^{''}|h^{''},\epsilon_n^{''}|h^{''},\eta^{''}|\eta^{'},\omega^{''}|\eta^{''}} \Big[V^G(g_a(\bar{a}^{'},\mathbf{s}_1^{'},j+1),i^{''},h^{''},\epsilon_e^{''},\epsilon_n^{''},\eta^{''},\omega^{''},j+2)\Big]$$

Since there is no debt, the agent do not default. Thus, $L^0(\bar{a}^{'},\eta^{'};\bar{a}^{'}) = V^G(\bar{a}^{'},\mathbf{s}_1^{'}) = v^{G,N}(\bar{a}^{'},\mathbf{s}_1^{'})$ and $L(a^{'},\eta^{'};\bar{a}^{'}) \leq V^G(a^{'},\mathbf{s}_1^{'})$ for all $a^{'} \geq 0$. Moreover, $L(a^{'},\eta^{'};\bar{a}^{'})$ is differentiable at $\bar{a}^{'}$. Therefore, $L(\cdot,\eta^{'};\bar{a}^{'})$ is a lower differentiable support function of $V^G(\bar{a}^{'},\mathbf{s}_1^{'})$.
(ii) Case2: $a_{rbl}(\bar{i}^{'},\bar{h}^{'};j,\eta) < \bar{a}^{'} < 0$.
Let us consider a case for realized value $(a^{'},\eta^{'})$, a household takes $a^{''} = g_a(\bar{a}^{'},\mathbf{s}_1^{'},j+1)$ for all $a^{'}$ and $\eta^{'}$. Let us define this agent's net value function $L^1(a^{'},\eta^{'};\bar{a}^{'})$ in the following way:

$$\begin{aligned} L^1(a^{'},\eta^{'};\bar{a}^{'},\mathbf{s}_1^{'}) = \max\Bigg\{ & u\Big(w\bar{\omega}_j h_c \eta^{'} + a^{'} - (1-q_i)(m_n^{'} + m_e(\epsilon_e^{'})) \\ & -T(y^{'}) + \kappa^{'} - q - q(g_a(a^{'},\mathbf{s}_1^{'},j+1),i^{''},h^{''};\eta^{'},j+1)g_a(a^{'},\mathbf{s}_1^{'},j+1) - p_{i''}, h_c^{'}\Big) \\ & +\beta\pi_{j+2|j+1}(h_c^{'},j_g) \mathop{\mathbb{E}}_{\epsilon_e^{''}|h^{''},\epsilon_n^{''}|h^{''},\eta^{''}|\eta^{'},\omega^{''}|\eta^{''}} \Big[V^G(g_a(\bar{a}^{'},\mathbf{s}_1^{'},j+1),i^{''},h^{''},\epsilon_e^{''},\epsilon_n^{''},\eta^{''},\omega^{''},j+2)\Big], \\ & u\Big(w\bar{\omega}_j h_c \eta^{'} - (1-q_i)m_n^{'} - T(y^{'}) + \kappa^{'} - p_{i''}, h_c^{'}\Big) \\ & +\beta\pi_{j+2|j+1}(h_c^{'},j_g) \mathop{\mathbb{E}}_{\epsilon_e^{''}|h^{''},\epsilon_n^{''}|h^{''},\eta^{''}|\eta^{'},\omega^{''}|\eta^{''}} \Big[V^B(0,i^{''},h^{''},\epsilon_e^{''},\epsilon_n^{''},\eta^{''},\omega^{''},j+2)\Big] \Bigg\} \end{aligned} \tag{29}$$

$L^1(\bar{a}^{'},\eta^{'};\bar{a}^{'}) = V^G(\bar{a}^{'},\mathbf{s}_1^{'})$ and $L^1(a^{'},\eta^{'};\bar{a}^{'}) \leq V^G(a^{'},\mathbf{s}_1^{'})$ for all $a^{'} \geq 0$. Moreover, $L(a^{'},\eta^{'};\bar{a}^{'})$ is differentiable with respect to $a^{'}$. Therefore, $L^1(\cdot,\eta^{'};\bar{a}^{'})$ is a lower differentiable support function of $V^G(\bar{a}^{'},\mathbf{s}_1^{'})$.

□

Appendix D Recursive Equilibrium

I define a measure space to describe equilibrium. To ease notation, I denote $\mathbf{S} = \mathbf{A} \times \mathbf{I} \times \mathbf{H} \times \mathbf{ER} \times \mathbf{NER} \times \mathbf{E} \times \mathbf{O} \times \Upsilon$ as the state space of households, where $\mathbf{A}$ is the space of households' assets a, $\mathbf{I}$ is the space of households' health insurance i, $\mathbf{H}$ is the space of households' health capital h, $\mathbf{ER}$ is the space of emergency health shocks ϵ_e, $\mathbf{NER}$ is the space of non-emergency health shocks ϵ_n, $\mathbf{O}$ is the space of the offer of employer-based health insurance ω and Υ is the space of credit status $\upsilon \in \{G, B\}$. In addition, let $\mathbb{B}(\mathbf{S})$ denote the Borel σ-algebra on $\mathbf{S}$. In addition, I denote $\mathbf{J} = \{J_0, \cdots, J_r, \cdots, \bar{J}\}$ as the space of households' age. Then, for each age j, a probability measure $\mu(\cdot, j)$ is defined on the Borel σ-algebra $\mathbb{B}(\mathbf{S})$ such that $\mu(\cdot, j) : \mathbb{B}(\mathbf{S}) \longrightarrow [0, 1]$. $\mu(B, j)$ represents the measure of age j households at time t whose state lies in $B \in \mathbb{B}(\mathbf{S})$ as a proportion of all age j. The households' distribution at age j in age group j_g evolves as follows: For all $B \in \mathbb{B}(\mathbf{S})$,

$$\mu(B, j+1) = \int_{\left\{\mathbf{s} \mid \left(g_a(\mathbf{s},j), g_i(\mathbf{s},j), g_h(\mathbf{s},j), \epsilon_e', \epsilon_n', \eta', \omega', \upsilon'\right) \in B\right\}} \left[\Gamma_\upsilon^{\upsilon'} \; \pi_{j+1|j}(h_c, j_g) \; \pi_{\epsilon_e'|g_h(\mathbf{s},j)} \; \pi_{\epsilon_n'|g_h(\mathbf{s},j)} \; \pi_{\eta'|\eta} \; \pi_{\omega'|\eta'}\right] \; \mu(d\mathbf{s}, j) \tag{30}$$

, where $\mathbf{s} = (a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, \upsilon) \in \mathbf{S}$ is the individual state. $g_a(\cdot, j)$ is the policy function for assets at age j, $g_i(\cdot, j)$ is the policy function for health insurance at age j, and $g_h(\cdot, j)$ is the policy function for health investment at age j. In addition, $\Gamma_\upsilon^{\upsilon'}$ is the transitional probability of credit status υ' in the next period conditional on the current credit status υ, $\pi_{j+1|j}(h_c, j_g)$ is the rate of surviving up to age $j+1$ conditional on surviving up to age j with the current health status h_c in age group j_g and $\pi_{\epsilon_e'|g_h(\mathbf{s},j)}$ ($\pi_{\epsilon_n'|g_h(\mathbf{s},j)}$) is the transition probability for ϵ_e' (ϵ_n') conditional on $g_h(\mathbf{s}, j)$. $\pi_{\eta'|\eta}$ is the transitional probability of idiosyncratic labor productivity for next period η' conditional on η and $\pi_{\omega'|\eta'}$ is the probability of receiving an employer-based health insurance offer ω' for next period conditional on η'. Let us define $\mathbf{M}$ as the collection of these probability measures $\mu(\cdot, j)$ over age j.

Definition D.0.1 (***Recursive Competitive Equilibrium***)**.** Given an initial distribution M^*, an distribution of newborn agents $B_0 \in \mathbf{S}$, a social Security benefit ss, a Medicare coverage rate q_{med}, a Medicare premium p_{med}, a subsidy rule for employer-based health insurance ψ_{EHI}, mark-up of health private insurances ν_{IHI} and ν_{EHI}, a sequence of the income threshold for Medicaid eligibility $\{\bar{y}_t\}_{t=0}^{\infty}$, a sequences of health insurance coverage rates $\{q_{MDC_t}, q_{IHI_t}, q_{EHI_t}\}_{t=0}^{\infty}$, a sequence of the private individual health insurance pricing rule $\{\{p_{IHI,t}(\cdot, j_g)\}_{j_g=1}^{4}\}_{t=0}^{\infty}$, a sequence of subsidies for private individual health insurances $\{\psi_{EHI,t}(\cdot,\cdot)\}_{t=0}^{\infty}$, a tax policy, $\{T_t(\cdot), \tau_{ss,t}, \tau_{med,t}\}_{t=0}^{\infty}$, a recursive competitive equilibrium is
a sequence of prices $\left\{w_t, r_t^{rf}, r_t, q_t^{rf}, \{q_t(\cdot,\cdot,\cdot,j,\cdot)\}_{j=J_0}^{J_r-1}, \{p_t(\cdot, j)\}_{j_g=1}^{4}, p_{med,t}\right\}_{t=0}^{\infty}$

, a sequence of the mark-up of hospital $\{\zeta_t\}_{t=0}^{\infty}$
, a sequence of decision rules for households $\left\{\{g_{d,t}(\cdot,j), g_{a,t}(\cdot,j), g_{i,t}(\cdot,j), g_{h,t}(\cdot,j)\}_{j=J_0}^{\bar{J}}\right\}_{t=0}^{\infty}$
, a sequence of default probability function $\left\{d_t(\cdot,\cdot,\cdot;j,\cdot)\}_{j=J_0}^{\bar{J}}\right\}_{t=0}^{\infty}$
, a sequence of values $\left\{\left\{V_t^G(\cdot,j), v_t^{G,N}(\cdot,j), v_t^{G,D}(\cdot,j), V_t^B(\cdot,j), v_t^{B,N}(\cdot,j), v_t^{B,D}(\cdot,j)\right\}_{j=J_0}^{J_r-1},\right.$
$\left.\left\{v_t^{G,r}(\cdot,j), v_t^{B,r}(\cdot,j)\right\}_{j=J_r}^{\bar{J}}\right\}_{t=0}^{\infty}$
and a sequence of the distribution of households $\{M_t\}_{t=0}^{\infty}$ such that

(i) Given prices, the policies above, the decision rules $g_{d,t}(\mathbf{s},j)$, $g_{a,t}(\mathbf{s},j)$, $g_{i,t}(\mathbf{s},j)$ and $g_{h,t}(\mathbf{s},j)$ solve the household problems (19)-(C) and $V_t^G(\cdot,j), v_t^{G,N}(\cdot,j), v_t^{G,D}(\cdot,j), V_t^B(\cdot,j)$, $v_t^{B,N}(\cdot,j), v_t^{B,D}(\cdot,j), v_t^{G,r}(\cdot,j)$ and $v_t^{B,r}(\cdot,j)$ are the associated value functions.

(ii) Firm is competitive pricing:

$$w_t = \frac{\partial z_t F(K_t, N_t)}{\partial N_t}, \quad r_t = \frac{\partial z_t F(K_t, N_t)}{\partial K_t}$$

, where K_t is the quantity of aggregate capital, and $N_t$is the quantity of aggregate labor.

(iii) Loan prices and default probabilities are consistent, whereby lenders earn zero expected profits on each loan of size a' for households that have health insurance i' for next period, health capital h' for next period, the current idiosyncratic shock on earnings η at age j:

$$q_t(a',i',h';j,\eta) = \frac{(1-d_t(a',i',h';j,\eta))}{1+r_{t+1}^{rf}}$$
$$d_t(a',i',h';j,\eta) = \sum_{\epsilon_n',\epsilon_e',\eta',\omega'} \pi_{\epsilon_e'|h'}\pi_{\epsilon_n'|h'}\pi_{\eta'|\eta}\pi_{\omega'|\eta'}\mathbb{1}_{\{v_{t+1}^{G,N}(\mathbf{s}_n',j+1)\le v_{t+1}^{G,D}(\mathbf{s}_d',j+1)\}}$$

, where $s_n' = (a',i',h',\epsilon_e',\epsilon_n',\eta',\omega',j+1)$ and $s_d' = (i',h',\epsilon_e',\epsilon_n',\eta',\omega',j+1)$.

(iv) The hospital has zero profit:

$$\sum_{j=J_0}^{\bar{J}}\int\left\{[m_{n,t}(\mathbf{s},j)+(1-g_{d,t}(\mathbf{s},j))m_e(\epsilon_{e,t})+g_{d,t}(\mathbf{s},j)\max(a,0)]\right.$$
$$\left.-\frac{(m_{n,t}(\mathbf{s},j)+m_e(\epsilon_{e,t}))}{\zeta_t}\right\}\mu_t(d\mathbf{s},j) = 0.$$

(v) The bond market and the capital market are clear:

$$\begin{aligned}
r_t^{rf} &= r_t - \delta \\
q_t^{rf} &= \frac{1}{1 + r_t^{rf}} \\
K_{t+1} &= \sum_{j=J_0}^{\bar{J}} \Bigg[\int \Big(q(g_{a,t}(\mathbf{s}, j), g_{i,t}(\mathbf{s}, j), g_{h,t}(\mathbf{s}, j); j, \eta) g_{a,t}(\mathbf{s}, j) \\
&\quad + (p_t(g_{i,t}, h_c, j_g) \cdot \mathbb{1}_{\{g_{i,t}(\mathbf{s},j) \in \{IHI, EHI\}} \Big) \mu_t(d\mathbf{s}, j) \Bigg].
\end{aligned}$$

(vi) The labor market is clear:

$$N_t = \sum_{j=J_0}^{J_r - 1} \left[\bar{\omega}_j \int \left((1 - \epsilon_e)(1 - \epsilon_n) h \eta \right) \mu_t(d\mathbf{s}, j) \right].$$

(vii) The goods market is clear:

$$\underbrace{\sum_{j=J_0}^{\bar{J}} \left[\int \left(c_t(\mathbf{s},j) + \frac{m_{n,t}(\mathbf{s},j) + m_e(\epsilon_{e,t})}{\zeta_t} \right) \mu_t(d\mathbf{s},j) \right]}_{\text{Aggregate Non-medical Consumption + Aggregate Medical Expenditures}} + \underbrace{K_{t+1} - (1-\delta)K_t}_{\text{Aggregate Investment}}$$

$$+ \underbrace{G_t}_{\text{Government Spending Irrelevant to Health Insurance}}$$

$$+ \sum_{j=J_0}^{J_r-1} \left[\int \underbrace{\Big\{ \left(\psi_{IHI,t}(p_{IHI,t}(h_c, j_g), y(\mathbf{s},j)) \cdot \mathbb{1}_{\{g_{i,t}(\mathbf{s},j)=IHI\}} \right)}_{\text{Government Subsidy for Private Individual Health Insurance IHI}} \right.$$

$$\left. + \underbrace{\left(\psi_{EHI} \cdot p_{EHI,t} \cdot \mathbb{1}_{\{g_{i,t}(\mathbf{s},j)=EHI\}} \right) \Big\}}_{\text{Government Subsidy for Employer-Based Health Insurance EHI}} \mu_t(d\mathbf{s},j) \right]$$

$$= \underbrace{z_t F(K_t, N_t)}_{\text{Total Output}}$$

$$\underbrace{- \chi w_t \sum_{j=J_0}^{J_r-1} \left[\bar{\omega}_j \int \left((1-\epsilon_e)(1-\epsilon_n) h_c g_{d,t}(\mathbf{s},j) \right) \mu_t(d\mathbf{s},j) \right]}_{\text{Deadweight Loss from Default}}$$

$$- \underbrace{\sum_{j=J_0}^{J_r-1} \left[\int \left(\nu_{g_{i,t}} p_t(g_{i,t}, h_c, j_g) \mathbb{1}_{\{g_{i,t}(\mathbf{s},j) \in \{IHI,EHI\}\}} \right) \mu_t(d\mathbf{s},j) \right]}_{\text{Deadweight Loss due to the Mark-up of Private Health Insurance Markets}}.$$

(viii) The insurance markets are clear:

For each age group j_g and each health group h_g, the premium of the private individual health insurance $p_{IHI,t}(h_g, j_g)$ satisfies

$$\underbrace{(1+\nu_{IHI})}_{\text{Mark-up of IHI}} \underbrace{\sum_{j \in J_g} \int q_{IHI,t} \cdot \mathbb{1}_{\{\{i=IHI\} \cap \{h \in h_g\}\}} \cdot (m_{n,t}(\mathbf{s},j) + m_e(\epsilon_{e,t})) \mu_t(d\mathbf{s},j)}_{\text{Total Medical Expenditure Covered by IHI}}$$

$$= (1 + r_t^{rf})\, p_{IHI,t}(h_g, j_g) \underbrace{\sum_{j \in J_g} \int \mathbb{1}_{\{\{g_{i,t}(\mathbf{s},j)=IHI\} \cap \{h \in h_g\}\}} \mu_t(d\mathbf{s},j)}_{\text{Total Demand of IHI}}.$$

The premium of the employer-based health Insurance $p_{EHI,t}$ satisfies

$$\underbrace{(1+\nu_{EHI})}_{\text{Mark-up of EHI}}\underbrace{\sum_{j=J_0}^{J_r-1}\int q_{EHI}\cdot \mathbb{1}_{\{i=EHI\}}(m_{n,t}(\mathbf{s},j)+m_e(\epsilon_{e,t}))\mu_t(d\mathbf{s},j)}_{\text{Total Medical Expenditure Covered by EHI}}$$

$$=(1+r_t^{rf})\cdot p_{EHI}\cdot \underbrace{\sum_{j=J_0}^{J_r-1}\int \mathbb{1}_{\{g_{i,t}(\mathbf{s},j)=EHI\}}\mu_t(d\mathbf{s},j)}_{\text{Total Demand for EHI}}.$$

(ix) Social security (ss) and Medicare are financed by their own objective payroll taxes τ_{ss} and τ_{med}. The government budget constraint is balanced:

$$\underbrace{\sum_{j=J_r}^{\bar{J}}\int (ss)\mu_t(d\mathbf{s},j)}_{\text{Total Social Security Benefit}}=\underbrace{\sum_{j=J_0}^{J_r-1}\int \tau_{ss}\, w\bar{\omega}_j h_c\eta\mu_t(d\mathbf{s},j)}_{\text{Revenue from Social Security Tax}}$$

$$\sum_{j=J_r}^{\bar{J}}\int\left(\underbrace{q_{med}(m_{n,t}(\mathbf{s},j)+m_e(\epsilon_{e,t}))}_{\text{Medical Expenses Covered by Medicare}}-\underbrace{p_{med}}_{\text{Medicare Premium}}\right)\mu_t(d\mathbf{s},j)=\underbrace{\sum_{j=J_0}^{J_r-1}\int \tau_{med}\, w\bar{\omega}_j h_c\eta\mu_t(d\mathbf{s},j)}_{\text{Revenue from Medicare Tax}}$$

$$\underbrace{G_t}_{\text{Government Spending}}+\sum_{j=J_0}^{J_{r-1}}\left[\int\left\{\underbrace{\left(\psi_{IHI,t}(p_{IHI,t}(h_c,j_g),y(\mathbf{s},j))\cdot \mathbb{1}_{\{g_{i,t}(\mathbf{s},j)=IHI\}}\right)}_{\text{Subsidy for IHI}}\right.\right.$$

$$\left.\left.+\underbrace{\left(\psi_{EHI}\cdot p_{EHI,t}\cdot \mathbb{1}_{\{g_{i,t}(\mathbf{s},j)=EHI\}}\right)}_{\text{Subsidy for EHI}}\right\}\mu_t(d\mathbf{s},j)\right]=\underbrace{\sum_{j=0}^{J}\int T_t(y)\mu_t(d\mathbf{s},j)}_{\text{Revenue from Income Tax}}.$$

(x) Law of Motion for $\mathbf{M}_t$:

$$\mathbf{M}_{t+1}=H_t(\mathbf{M_t}).$$

The function H_t is as follows:

(a) For all $(B\times D)\in \mathbf{S}\times\mathbf{J}$ such that $1\notin D$,

$$\mathbf{M}_{t+1}(B\times D)=\sum_{j=J_0}^{\bar{J}}\int Q_t((\mathbf{s},j);B\times D)\,M_t(d\mathbf{s},j)$$

, where Q_t is the transitional function defined as:

$$Q_t((\mathbf{s},j);B\times D)=\Big[\Gamma_{\upsilon}^{\upsilon'}\ \pi_{j+1|j}(h_c,j_g)\ \pi_{\epsilon_e'|g_{h,t}(\mathbf{s},j)}\ \pi_{\epsilon_n'|g_{h,t}(\mathbf{s},j)}\ \pi_{\eta'|\eta}\ \pi_{\omega'|\eta'}\Big]$$
$$\times\ \mathbb{1}_{\big\{\mathbf{s}\times j|(g_{a,t}(\mathbf{s},j),g_{i,t}(\mathbf{s},j),g_{h,t}(\mathbf{s},j),\epsilon_e',\epsilon_n',\eta',\omega',\upsilon',j+1)\in B\times D\big\}}.$$

(b) For all $(B\times 1)\in\mathbf{S}\times\mathbf{J}$

$$\mathbf{M}_{t+1}(B\times 1)=\Pi(B)\times\mathbb{1}_{\{B_0\in B\}}.$$

(xi) Accidental bequests κ are evenly distributed to all of the households:

$$\kappa_t=\sum_{j=J_0}^{\bar{J}-1}\bigg(\int[(1-\pi_{j+1|j}(h_c,j_g))(a_{t+1}\,(1+r_{t+1}^{rf}))\cdot\mathbb{1}_{\{a_{t+1}>0\}}]\mu_t(d\mathbf{s},j)\bigg).$$

Appendix E Data Details

E.1 Data Cleansing

I choose the MEPS waves from 2000 to 2011. Among various data files in MEPS, by using individual id (DUPERSID), I merger three types of data files: MEPS Panel Longitudinal files, Medical Condition files, and Emergency Room visits files. To clean this data set, I take the following steps. First, I identify household units with the Health Insurance Eligibility Unit (HIEU). Second, I define household heads who have the highest labor income within a HIEU. I eliminate households in which the heads are non-respondents for key variables such as demographic features, educational information, medical expenditures, health insurance, health status, and medical conditions. Second, among working age (23-64) head households, I drop families that have no labor income. Third, I use the MEPS longitudinal weight in MEPS Panel Longitudinal file for each individual. Since each survey of MEPS Panel Longitudinal files covers 2 consequent years, I stack individuals in the 10 different panels into one data set. To use the longitudinal weight with my stacked data set, I follow the way in Jeske and Kitao (2009). As they did, I rescale the longitudinal weight in each survey to make the sum of the weight equal to the number of HIEUs. In this way, I address the issues of different size of samples across surveys and reflect the longitudinal weight in each survey. Lastly, I convert all nominal values into the value of US dollar in 2000 with the CPI. The number of observations in each panel is as follows.

Year	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006
Numbers	5218	10187	7484	7577	7548	7294
Year	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	
Numbers	7721	5835	8611	7988	7020	

Table 13: MEPS Panel Sample Size

E.2 Variable Definitions

Household Unit(MEPS Panel Longitudinal files, Medical Condition files, and Emergency Room visits files): To define households, I use the Health Insurance Eligibility Units (HIEU) in the MEPS. To capture behaviors related to health insurance, the HIEU is a more proper id than dwelling unit. Since the HIEU is different from dwelling unit, even within a dwelling unit, multiple HIEUs can exist. A HIEU includes spouses, unmarried natural or adoptive children of age 18 or under and children under 24 who are full-time students.

Head(MEPS Panel Longitudinal files): The MEPS does not formally define heads in households. I define head by choosing the highest earner within a HIEU.

Household Income (MEPS Panel Longitudinal files): The MEPS records individual total income (TTLPY1X and TTPLY2X). Household income is the summation of all house members total income.

Medical Expenditures (MEPS Panel Longitudinal files): The MEPS provides information on individual total medical expenditures (TOTEXPY1 and TOTEXPY2). However, this variable includes medical expenditures paid for by Veterans Affairs (TOTVAY1 and TOTVAY2), Workmans Compensation (TOTWCPY1 and TOTWCPY2) and other sources (TOTOSRY1 and TOTOSRY2) that are not covered in this study, I redefine the total medical expenditure variable by subtracting these three variables from the original total medical expenditure variable.

Insurance Status(MEPS Panel Longitudinal files): For working age head households, I categorize four type of health insurance status: uninsured, Medicaid, individual health insurance, and employer-based health insurance. The MEPS records whether each respondent has a health insurance, whether the insurance is provided by the government or private sectors (INSCOVY1 and ISCOVY2), and whether to use Medicaid (MCDEVY1 and MCDEVY2). Using this variable, I define the uninsured and Medicaid users. The MEPS also records employer-based health insurance holders (HELD1X, HELD2X, HELD3X, HELD4X, HELD5X) for five subsequent survey periods. I define employer-based health insurance holders who have experience in holding employer-based health insurance within a year. I define individual health insurance holders as those who do not have employer-based health insurance (HELD1X, HELD2X, HELD3X, HELD4X, HELD5X) but have a private health insurance (INSCOVY1 and INSCOVY2).

Employer-Based Health Insurance Offer rate (MEPS Panel Longitudinal files): The MEPS provides information as to whether respondents employer offers health insurance (OFFER1X, OFFER2X, OFFER3X, OFFER4X, OFFER5X).

Medical Conditions (Medical Condition files): The Medical Condition Files in the MEPS keeps track of individual medical condition records with various measures. I choose Clinical Classification Code for identifying individual medical conditions (CCCODEX).

Health Shocks (Medical Condition files and morbidity measures from the WHO): In order to quantify these individual medical conditions, I use a measure from the World Health Organization (WHO). The WHO provides two types of measures to quantify the burden of diseases: mortality measures (years of life lost to illness (YLL) and morbidity measures (years lived with disability (YLD)). I use the adjusted morbidity measure in the study of Prados (2012). Table **??** is the morbidity measures in Prados (2012). For calculating health shocks from medical conditions, I follow the method in Prados (2012). Lets assume that a household has D medical conditions. Denote d_i as the WHO index for medical condition i, where $i = 1, \ldots, D$. For this household, its health

Condition	Disab. Wgt.	Condition	Disab. Wgt.
Tuberculosis	0.23	Aortic, peripheral, and visceral artery aneurysms	0.29
Bacterial infection, unspecified site	0.04	Aortic and peripheral arterial embolism	0.29
Mycoses	0.00	Other circulatory disease	0.13
Hiv infection	0.57	Phlebitis, thrombophlebitis and thromboembolism	0.13
Hepatitis	0.08	Pneumonia (except that caused by tuberculosis or sexual	0.04
Viral infection	0.01	Influenza	0.01
Other infections, including parasitic	0.02	Acute and chronic tonsillitis	0.00
Sexually transmitted infections (not HIV or hepatitis)	0.07	Acute bronchitis	0.00
Cancer of head and neck	0.20	Other upper respiratory infections	0.00
Cancer of stomach	0.33	Chronic obstructive pulmonary diseas	0.23
Cancer of colon	0.22	Asthma	0.23
Cancer of rectum and anus	0.22	Pleurisy, pneumothorax, pulmonary collapse	0.23
Cancer of liver and intrahepatic bile duct	0.20	Respiratory failure, insufficiency, arrest	0.23
Cancer of pancreas	0.20	Lung disease due to external agents	0.04
Cancer of bronchus, lung	0.43	Other lower respiratory disease	0.04
Cancer of bone and connective tissue	0.06	Other upper respiratory disease	0.00
Melanomas of skin	0.06	Intestinal infection	0.02
Other non-epithelial cancer of skin	0.06	Gastroduodenal ulcer (except hemorrhage)	0.02
Cancer of breast	0.27	Gastritis and duodenitis	0.02
Cancer of uterus	0.10	Appendicitis and other appendiceal conditions	0.46
Cancer of cervix	0.08	Regional enteritis and ulcerative collitis	0.02
Cancer of ovary	0.10	Intestinal obstruction without hernia	0.02
Cancer of other female genital organs	0.10	Diverticulosis and diverticulitis	0.20
Cancer of prostate	0.34	Peritonitis and intestinal abscess	0.20
Cancer of testis	0.09	Nephritis, nephrosis, renal sclerosis	0.09
Cancer of bladder	0.09	Acute and unspecified renal failure	0.09
Cancer of kidney and renal pelvis	0.09	Chronic renal failure	0.10
Cancer of brain and nervous system	0.09	Urinary tract infections	0.01
Cancer of thyroid	0.09	Hyperplasia of prostate	0.04
Hodgkin's disease	0.06	Inflammatory diseases of female pelvic organs	0.33
Non-hodgkin's lymphoma	0.31	Endometriosis	0.10
Leukemias	0.09	Prolapse of female genital organs	0.10
Cancer, other and unspecified primary	0.09	Ovarian cyst	0.10
Secondary malignancies	0.75	Female infertility	0.11
Malignant neoplasm without specification of site	0.09	Ectopic pregnancy	0.55
Neoplasms of unspecified nature or uncertain behavior	0.09	Skin and subcutaneous tissue infection	0.07
Maintenance chemotherapy, radiotherapy	0.09	Other inflammatory condition of skin	0.07
Benign neoplasm of uterus	0.09	Chronic ulcer of skin	0.07
Other and unspecified benign neoplasm	0.09	Other skin disorders	0.07
Diabetes mellitus without complication	0.20	Rheumatoid arthritis and related disease	0.53
Diabetes mellitus with complications	0.20	Osteoarthritis	0.19
Nutritional deficiencies	0.03	Spondylosis, intervertebral disc dis	0.06
Gout and other crystal arthropathies	0.13	Joint disorders and dislocations, trauma related	0.07
Deficiency and other anemia	0.05	Fracture of neck of femur (hip)	0.19
Sickle cell anemia	0.05	Spinal cord injury	0.73
Meningitis (except that caused by tuberculosis or std)	0.31	Skull and face fractures	0.43
Parkinson's disease	0.68	Fracture of upper limb	0.19
Multiple sclerosis	0.53	Fracture of lower limb	0.19
Paralysis	0.57	Other fractures	0.19
Epilepsy, convulsions	0.11	Sprains and strains	0.06
Headache, including migraine	0.03	Intracranial injury	0.36
Cataract	0.10	Crushing injury or internal injury	0.22
Retinal detachments, defects, vascular occlusion and reti	0.10	Open wounds of head, neck, and trunk	0.17
Glaucoma	0.10	Open wounds of extremities	0.17
Blindness and vision defects	0.10	Superficial injury, contusion	0.17
Otitis media and related conditions	0.02	Burns	0.16
Other ear and sense organ disorders	0.07	Poisoning by other medications and d	0.17
Other nervous system disorders	0.50	Poisoning by nonmedicinal substances	0.17
Heart valve disorders	0.13	Other injuries and conditions due to	0.17
Peri-, endo-, and myocarditis, cardiomyopathy	0.32	Nausea and vomiting	0.00
Essential hypertension	0.25	Abdominal pain	0.00
Hypertension with complications and secondary hyperte	0.25	Malaise and fatigue	0.00
Acute myocardial infarction	0.15	Allergic reactions	0.00
Coronary atherosclerosis and other heart disease	0.29	Adjustment disorder	0.02
Pulmonary heart disease	0.13	Anxiety disorder	0.17
Other and ill-defined heart disease	0.13	Attention-deficit, conduct, and disruptive behavior disor	0.17
Conduction disorders	0.13	Delirium, dementia, and amnestic and other cognitive di	0.71
Cardiac dysrhythmias	0.13	Developmental disorders	0.02
Cardiac arrest and ventricular fibri	0.15	Impulse control disorders	0.13
Congestive heart failure, nonhyperte	0.15	Mood disorders	0.23
Acute cerebrovascular disease	0.61	Personality disorders	0.66
Occlusion or stenosis of precerebral arteries	0.61	Schizophrenia and other psychotic disorders	0.66
Other and ill-defined cerebrovascular disease	0.61	Alcohol-related disorders	0.55
Transient cerebral ischemia	0.61	Substance-related disorders	0.55
Late effects of cerebrovascular dise	0.61	Suicide and intentional self-inflict	0.23
Peripheral and visceral atherosclero	0.29		

Table 14: Disability Weights (Source:Prados (2012))

shock ϵ_h is represented by

$$(1 - \epsilon_h) = \prod_{i=1}^{D} (1 - d_i). \tag{31}$$

This measure well represents the features of medical condition in the sense that it reflects not only multiple medical conditions but also differences in their severity.

Emergency Room Usages and Charges (Emergency Room Visits files): Emergency Room Visits files in the MEPS record respondents who visit emergency rooms. These files records the Clinical Classification Code as to why respondents visit emergency rooms (ERCCC1X, ERCCC2X, ERCCC3x) and as to how much hospitals charge from emergency medical events to patients (ERTC00X).

Appendix F Computation Details

There are computational burdens in this problem, because not only the dimension of individual state is large, but also the value functions of the model are involved with many non-concave and non-smooth factors: the choice of default, health insurance, medical cost, and progressive subsidy or tax policies.

To solve the model with these complexities, I use Jang and Lee's (2018) endogenous grid method. This method is a extended version of Fella's (2014) endogenous grid method. He provides an algorithm to handle non-concavities on the value functions with an exogenous borrowing constraint. Jang and Lee (2018) generalize the method for default problems in which borrowing constraints differ across individuals.

Whereas there are several types of value functions in the model, the computational issues are mainly related to four types of value functions: the value function of non-defaulting households with good (bad) credit status $v^{G,N}$ ($v^{B,N}$), the value function of retired households with good (bad) credit status $v^{G,r}$ ($v^{B,r}$). [23] The value function with bad credit status and two retired households' value functions are solved with the algorithm of Fella (2014), because in this case the economy has an exogenous borrowing constrain with discrete choice, which is consistent with the setting of Fella (2014). The method of Jang and Lee (2018) is for solving the value function of repaying debts $v^{G,R}$ in which borrowing constraints differ across individuals states.

In the following subsections, first, I demonstrate how to solve the value of non-defaulting households with good credit status $v^{G,N}$ with the endogenous grid method of Jang and Lee (2018).[24] Then, I show how to solve the other value functions with the endogenous grid method of Fella (2014).

F.1 Notation and Discretization of States

Before getting into details, let us begin with notations to explain the algorithm. To ease notation, I denote $\mathrm{s}_{-a} = (i, h, \epsilon_e, \epsilon_n, \eta, \omega, j)$ and $\mathrm{s}_p^{'} = (i^{'}, h^{'}, \eta, j+1)$. Then, $V^G(a, \mathrm{s}_{-a}) = V^G(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j)$ and $q(a^{'}, \bar{i}^{'}, \bar{h}^{'}; j, \eta) = q(a^{'}, \mathrm{s}_p^{'})$. $G_{a^{'}} = \{a_1^{'}, \cdots, a_{N_{a^{'}}}^{'}\}$ and $G_O = \{O_1, \cdots, O_{N_O}\}$ are the grid of asset holdings $a^{'}$ and cash on hand O, respectively. I also denote $W^G(a^{'}, s_p) = W^G(a^{'}, i^{'}, h^{'}, \eta, j+1)$ as the expected value function of working households with good credit, $\mathbb{E}_{\epsilon_e^{'}|h^{'}, \epsilon_n^{'}|h^{'}, \eta^{'}|\eta, \omega^{'}|\eta^{'}}\left[V^G(a^{'}, \mathrm{s}_{-a}^{'})\right]$.

In the model, households need to make choices on three individual state variables: assets a, health insurance i, and health capital h. I discretize two endogenous states: health insurance i and health capital h. Assets a is considered as a continuous variable to which the endogenous

[23]The value function of filing for default is not involved with any continuous choice variable.

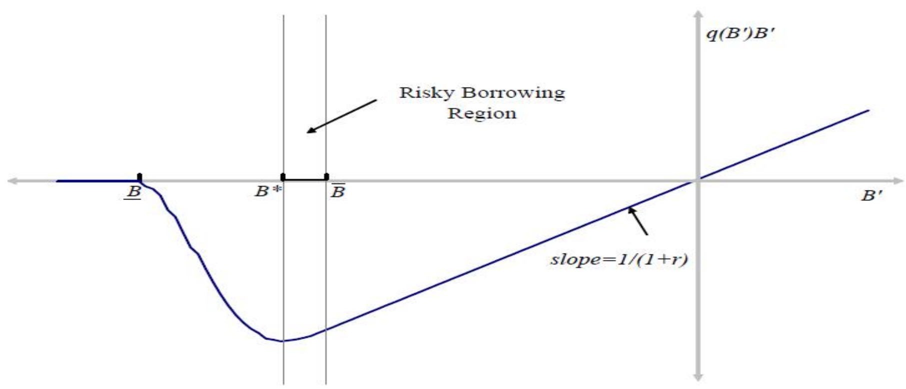
[24]This part hugely relies on the descriptions in Jang and Lee (2018).

grid method is used. This way is efficient because the variation of assets is the largest among the endogenous state variables. When solving the problems, I regard the choice of health insurance $\bar{i}'$ and health capital for next period $\bar{h}'$ as given states, and apply the endogenous grid method to asset holdings a' in the next period.

F.2 Calculating the Risky Borrowing Limit (Credit Limit) $(v^{G,N})$

Jang and Lee (2018) set up the feasible sets of the solution based on the work in Arellano (2008); Clausen and Strub (2017). They investigate the property of the risky borrowing limits (credit limits). They show that the size of loan $q(a')a'$ increases with a' for any optimal debt contract. If the size of loan $q(a')a'$ decreases in a^n, households can increase their consumption by increasing debts, which is not an optimal debt contract. Arellano (2008) (Clausen and Strub (2017)) defines the risky borrowing limit (credit limit) to be the lower bound of the set for optimal contract. For example, in Figure 7, B^* is the risky borrowing limit.

Figure 7: Risky Borrowing Limit (Arellano (2008))



For each state $s_p' = (\bar{i}', \bar{h}', j, \eta)$, I calculate the risky borrowing limit $a_{rbl}'(s_p')$ satisfying

$$\forall a' \geq a_{rbl}(s_p'), \frac{\partial q(a', s_p')a'}{\partial a'} = \frac{\partial q(a', s_p')}{\partial a'} a' + q(a', s_p') > 0. \tag{32}$$

I compute the numerical derivative of the discount rate of loan prices $q(a', s_p')$ over the grid of asset holdings $G_{a'}$ in the following way:

$$D_{a'}q(a_k', s_p') = \begin{cases} \frac{q(a_{k+1}', s_p') - q(a_k', s_p')}{a_{k+1}' - a_k'}, & \text{for } k < N_{a'} \\ \frac{q(a_k', s_p') - q(a_{k-1}', s_p')}{a_k' - a_{k-1}'}, & \text{for } k = N_{a'}. \end{cases} \tag{33}$$

I calculate the risky borrowing limit a_{rbl} for each state $s_p' = (\bar{i}', \bar{h}'; j, \eta)$ and fix them as the lower bound of the feasible set for the solution of asset holdings, a'. For each state $s_p' = (\bar{i}', \bar{h}'; j, \eta)$, I denote $G_{a'}^{rbl(s_p')}$ as the collection of all of the grid points for asset holdings a_k' above the risky borrowing limit $a_{rbl}(s_p')$, which means for all $a_k' \in G_{a'}^{rbl(s_p')}$, $a_k' > a_{rbl}(s_p')$.

F.3 Identifying (Non-) Concave Regions

It is worth noting that the FOC (17) is not sufficient but necessary, because of non-concavities on the expected value function $W^G(a', s_p')$ with respect to a'. If the concave regions can be identified, the FOC (17) is a sufficient and necessary condition for an optimal choice of asset holdings a' on the concave region. I use Fella's (2014) algorithm to divide the domain of the expected value functions $G_{a'}^{rbl(s_p')}$ into the concave and non-concave regions.

For each state $s_p' = (\bar{i}', \bar{h}', \eta, j+1)$, the concave region $G_{c_{a'}}$ is identified by two threshold grid points $\bar{a}'(s_p')$ and $\underline{a}'(s_p')$ that satisfy the following condition: for any $a_i' \in G_{a'}^{rbl(s_p')}$ and $a_j' \in G_{a'}^{rbl(s_p')}$ with $\bar{a}' < a_i' < a_j'$ ($a_i' < a_j' < \underline{a}'$), $D_{a'}W^G(a_i', s_p') > D_{a'}W^G(a_j', s_p')$.

To find the thresholds $\bar{a}'(s_p')$ and $\underline{a}'(s_p')$, I take the following steps. First, I check the discontinuous points of the derivative of the expected value function $D_{a'}W^G(a', s_p')$. I compute the derivative of the expected value function $D_{a'}W^G(a', s_p')$ in the same way as the derivative of the discount rate of loan price (33). Second, among the discontinuous points, I find the minimum value, which is $v_{max}(s_p')$. Third, I search for the maximum $a_i' \in G_{a'}^{rbl(\mathbf{s}_p')}$ satisfying $D_{a'}W^G(a', s_p') \leq v_{max}(s_p')$. The maximum is defined as $\bar{a}'(s_p')$. Fourth, among the discontinuous points, I find the maximum value, which is $v_{min}(s_p')$. Then, I search for the minimum $a_i' \in G_{a'}^{rbl(\mathbf{s}_p')}$ satisfying $D_{a'}W^G(a', s_p') \geq v_{min}(s_p')$.The minimum is defined as $\underline{a}'(s_p')$.

F.4 Computing the Endogenous Grid for the Cash on Hand

$$\frac{\partial q(a', \mathbf{s_p'})\mathbf{a}'}{\partial a'} \frac{\partial u(c, (1-\epsilon_e)(1-\epsilon_n)\bar{h})}{\partial c} = \frac{\partial W^G(a', \mathbf{s_p'})}{\partial a'}.$$

First, for each state $\mathbf{s}_p' = (\bar{i}', \bar{h}', \eta, j+1)$ and for each state $(\bar{h}, \epsilon_e, \epsilon_n)$, I retrieve the endogenously-driven consumption $c(a', \mathbf{s}_p')$ from the FOC (17). Since the utility function has a CES aggregator, the endogenously-driven consumption $c(a', \mathbf{s}_p')$ cannot be computed analytically. I use the bisection method to compute the endogenously-driven consumption $c(a', \mathbf{s}_p')$. Second, I compute the endogenously-determined cash on hand $O(a', \mathbf{s}_p') = c(a', \mathbf{s}_p') + q(a', \mathbf{s_p'})\mathbf{a}'$. Last, I store the pairs of $((a', \mathbf{s}_p'), O(a', \mathbf{s}_p'))$.

F.5 Storing the Value Function over the Endogenous Grid for Cash on Hand

For each state $s_p^{'} = (\bar{i}^{'}, \bar{h}^{'}, \eta, j+1)$ and for each state $(\bar{h}, \epsilon_e, \epsilon_n)$, I compute the value function $v^{G,N}$ over the endogenous grid for cash on hand, $O(a^{'}, s_p^{'})$, in the following way:

$$\tilde{v}^{G,N}(O(a^{'}, s_p^{'}), s_p^{'}) = u(O(a^{'}, s_p^{'}) - q(a^{'}, \mathbf{s_p^{'}})\mathbf{a}^{'}, (\mathbf{1}-\epsilon_{\mathbf{e}})(\mathbf{1}-\epsilon_{\mathbf{n}})\bar{\mathbf{h}}) + \mathbf{W^G}(\mathbf{a}^{'}, \mathbf{s}^{'}_{\mathbf{a_{-1}}}). \tag{34}$$

It is important to note that (i) (34) is irrelevant to any max operator and (ii) the value function $v^{G,N}(O(a^{'}, s_p^{'}), a^{'})$ is valued on the endogenous grid, not on the exogenous grid.

Computing the Value Function over the Exogenous Grid for Cash on Hand Using information about the identification of (non-) concave regions on asset holdings $a^{'}$ in subsection , I identify (non-) concave regions on cash on hand O.

Specifically, I take the following steps. First, I search for two threshold grid points in cash on hand $\bar{O}(s_p^{'}) = O(\bar{a}^{'}, s_p^{'})$ and $\underline{O}(s_p^{'}) = O(\underline{a}^{'}, s_p^{'})$. Then, if an $O > \bar{O}(s_p^{'})$ or $O < \underline{O}(s_p^{'})$, the FOC (17) provides a unique corresponding asset holdings $a^{'}$ for next period. It implies that for each state $s_p^{'}$, $\{O : O > \bar{O}(s_p^{'})\} \cap \{O : O < \underline{O}(s_p^{'})\}$ ($\{O : \underline{O}(s_p^{'}) \leq O \leq \bar{O}(s_p^{'})\}$) is the concave (non-concave) region on cash on hand.

When a grid point $O_k \in G_O$ is on the concave region, the FOC (17) is a sufficient and necessary condition of the global solution for asset holdings $a^{'}$. Thus, I use a linear interpolation to evaluate the value function $\tilde{v}^{G,N}(O, \mathbf{s_{-a}})$ and the policy function $(g_a^{G,N}(O, \mathbf{s_{-a}})$ on the concave region, and store them.

When a grid $O_k \in G_O$ is on the non-concave region, the FOC (17) is a necessary condition, which means that it provides candidates for the global solution for asset holdings $a^{'}$. I find the global solution out of these candidates in the following way. Given state $s_p^{'}$, I find a set of indexes I such that for any $i_o \in I$, $O(a_{i_o}^{'}, s_p^{'}) \leq O < O(a_{i_o+1}^{'}, s_p^{'})$ or $O(a_{i_o}^{'}, s_p^{'}) > O \geq O(a_{i_o+1}^{'}, s_p^{'})$. I take a linear interpolation to $a^{'}$: $a^{'}_{O_{i_o}} = \frac{O(a^{'}_{i_o+1})-O}{O(a^{'}_{i_o+1})-O(a^{'}_{i_o})} a^{'}_{i_o} + \left(1 - \frac{O(a^{'}_{i_o+1})-O}{O(a^{'}_{i_o+1})-O(a^{'}_{i_o})}\right) a^{'}_{i_o+1}$. Then, I find the global solution by solving the following problem:

$$\tilde{v}^{G,N}(O, \mathbf{s_p^{'}}) = \max_{\{\mathbf{a}^{'}_{\mathbf{O_{i_o}}} : \mathbf{i_o} \in \mathbf{I}\}} \mathbf{u}(\mathbf{O} - \mathbf{q}(\mathbf{a}^{'}_{\mathbf{O_{i_o}}}, \mathbf{s_p^{'}})\mathbf{a}^{'}_{\mathbf{O_{i_o}}}) + \mathbf{W^G}(\mathbf{a}^{'}_{\mathbf{O_{i_o}}}, \mathbf{s}^{'}_{-\mathbf{a}}). \tag{35}$$

I store the value function for non-defaulting households $\tilde{v}^{G,N}(O, \mathbf{s_p^{'}})$ and the policy function $g^{G,N}(O, \mathbf{s_p^{'}})$ on the non-concave region.

F.6 Interpolating the Value Function on the Grid for Assets

Since the level of assets a has a monotonic relation with cash on hand O, it is possible to interpolate the value function $\tilde{v}^{G,N}$ and decision rule $g^{G,N}$ over the exogenous grid of cash on hand G_O into the grid for assets G_a. Due to the non-linear progressive tax and insurance subsidies, for each grid point of the cash on hand $O_k \in G_O$, I find the corresponding asset by using the Newton-Raphson method. Then, using a linear interpolation, I evaluate the value function $\tilde{v}^{G,N}$ and decision rule $g^{G,N}$ on the grid for assets G_a.

F.7 Optimize the discrete choices

Until this step, the choice of health insurance $i^{'}$ and the status of invested health (medical expenditure) $h^{'}$ are given statuses. Optimize these two choices by searching the grid for each variable. The number of grid points for these variables is relatively smaller than that of grid points on asset a. Therefore, the computation is not so costly in this procedure. Formally, solve the following problems:

$$v^{G,N}(a, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j) = \max_{\{i^{'}, h^{'}\}} \tilde{v}^{G,N}(a, i^{'}, h^{'}, i, h, \epsilon_e, \epsilon_n, \eta, \omega, j)$$

F.8 Solving the Other Values

I use the grid search method to solve defaulting values $v^{G,D}$ and $v^{B,D}$, because they do not an intertemporal choice on assets and the number of grid points over health insurance i and health status h is relatively small.

For values of retired households $v^{G,r}$ and $v^{B,r}$ and values of non-defaulting households with bad credit status $v^{B,N}$, I apply Fella's (2014) endogenous grid method. It is almost the same as the previous steps other than F.2, as there is no unsecured debt in these problems. The lower bounds of feasible solution set are given by zero assets ($v^{B,N}$, $v^{B,r}$) or the natural borrowing limit ($v^{G,r}$). Precisely, with the predetermined borrowing limits, I take the steps of Section F.1 and Section F.3-Section F.6.

F.9 Updating the Expected Value Functions and Loan Prices Schedules for age $j - 1$

First, I update the value functions $V^G(\mathbf{s})$ and $V^B(\mathbf{s})$.

$$\begin{aligned} V^G(\mathbf{s}) &= \max\{v^{G,N}(\mathbf{s}), v^{G,D}(\mathbf{s_{-a}})\} \\ V^B(\mathbf{s}) &= \max\{v^{G,N}(\mathbf{s}), v^{G,D}(\mathbf{s_{-a}})\} \end{aligned} \tag{36}$$

Second, I update the expected value functions $W^G(\mathbf{s}_p)$ and $W^B(\mathbf{s}_p)$ for age $j-1$.

$$W^G(a^{'},i^{'},h^{'},\eta,j) = \sum_{\epsilon_n^{'},\epsilon_e^{'},\eta^{'},\omega^{'}} \pi_{\epsilon_e^{'}|h^{'}}\pi_{\epsilon_n^{'}|h^{'}}\pi_{\eta^{'}|\eta}\pi_{\omega^{'}|\eta^{'}}V^G(a^{'},i^{'},h^{'},\eta_e^{'},\eta_n^{'},\eta^{'},\omega^{'},j) \tag{37}$$

$$W^B(a^{'},i^{'},h^{'},\eta,j) = \sum_{\epsilon_n^{'},\epsilon_e^{'},\eta^{'},\omega^{'}} \pi_{\epsilon_e^{'}|h^{'}}\pi_{\epsilon_n^{'}|h^{'}}\pi_{\eta^{'}|\eta}\pi_{\omega^{'}|\eta^{'}}V^B(a^{'},i^{'},h^{'},\eta_e^{'},\eta_n^{'},\eta^{'},\omega^{'},j)$$

Last, the loan price function $q(a^{'},i^{'},h^{'};,j-1,\eta)$ is updated in the following way:

$$d(a^{'},i^{'},h^{'};j-1,\eta) = \sum_{\epsilon_n^{'},\epsilon_e^{'},\eta^{'},\omega^{'}} \pi_{\epsilon_e^{'}|h^{'}}\pi_{\epsilon_n^{'}|h^{'}}\pi_{\eta^{'}|\eta}\pi_{\omega^{'}|\eta^{'}}\mathbb{1}_{\{v^{G,N}(a^{'},i^{'},h^{'},\epsilon_e^{'},\epsilon_n^{'},\eta^{'},\omega^{'},j)\leq v^{G,D}(i^{'},h^{'},\epsilon_e^{'},\epsilon_n^{'},\eta^{'},\omega^{'},j)\}}$$

$$q(a^{'},i^{'},h^{'};j-1,\eta) = \frac{1-d(a^{'},i^{'},h^{'};j,\eta)}{1+r^{rf}}$$

, where $d(a^{'},i^{'},h^{'};j-1,\eta)$ is the expected default probability with state $(a^{'},i^{'},h^{'};j-1,\eta)$ at age $j-1$.

I repeatedly take the steps of Section F.1 - Section F.8 until the initial age.